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ORIGINAL ARTICLES.

I.—Glacial Geology of Western New York.[1]

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(WITH A MAP, PLATE XXI.)

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Physical Features.

Stratigraphy.

THE area herein described is that part of New York State lying south of Lake Ontario, and west of longitude 76°. The dimensions of the area are, approximately, 95 miles north and south and 155 miles east and west, or nearly 15,000 square miles. The rocks[2] are shales, sandstones, and limestones of the Upper Silurian and Devonian systems. The strike is nearly east and west, with a southward dip averaging perhaps 50 feet to the mile. The limestones are contained almost entirely in the lower strata and outcrop in the northern belt, where the surface has the lower altitude. The more arenaceous rocks form the elevated plateau of the middle and southern belts.

Topography.

The present surface configuration is a complex result of several agencies, which may be succinctly grouped as follows:—

[1] A paper read at the Toronto Meeting of the British Association, August, 1897.

[2] The stratigraphy is fully described in Dr. James Hall's Report, "Natural History of New York": Report on the Fourth Geological District, by James Hall. Albany, 1850.

1. Pre-Glacial subaerial erosion, probably effective since the close of the Palæozoic, and acting upon nearly horizontal strata of varying composition and resistance.

2. Glacial corrasion and transportation, supplemented both in the advance and retreat of the ice-sheet by the distributing and levelling action of glacial and morainal lakes.

3. The present brief period of renewed atmospheric and stream erosion.

The northern one-fourth of the area, forming a belt 25 miles wide along the south shore of Lake Ontario, was more deeply eroded by the Pre-Glacial agencies, as it contained all the limestones and the softer shales. It also suffered the greatest modification by the Glacial and lacustrine forces. It now forms a plain rising from about 300 feet elevation above tide near Lake Ontario to 600–700 feet at the distance of 25 miles south.

Southward the surface of the country rapidly rises into an elevated but irregular plateau, formed of the more enduring arenaceous strata, deeply gashed by stream erosion. The higher remnants of the plateau have an elevation considerably over 2,000 feet. The remarkable series of lakes known as the "Finger Lakes" occupy old stream-valleys along the northern border of this plateau.

Hydrography.

The waters of this area contribute to three great river systems. The greater part of the area is drained into the St. Lawrence, chiefly by the Genesee and the Oswego rivers, into Lake Ontario, only a minor tract draining into Lake Erie. The south-west corner of the State is drained by the Alleghany river into the Ohio-Mississippi, while the south-east part of the area is drained by the Susquehanna. The waters of the Mohawk-Hudson and of the Delaware lie beyond our eastern boundary.

The Genesee river is the only present stream which traverses the whole breadth of the State. Having its origin in Pennsylvania, it carries the line of water-parting between the Laurentian and the south-flowing waters beyond the southern limits of the State, and separates the Ohio-Mississippi and the Susquehanna drainage districts.

Few lakes occur in the streams of southern drainage. Excepting Chautauqua Lake, in the extreme south-west corner of the State, they are of insignificant size, and are all of glacial or morainal origin, and lie in cols or near the divide.

The series of large parallel lakes referred to above, lie along the north slope of the high plateau, and occupy ancient, deep river-valleys, whose channels have been partially blocked by drift, and further basined by the northward differential uplift of the region in Post-Glacial time.

Pre-Glacial Topography and Drainage.

The glacial and glacio-lacustrine agencies did not, it is believed, materially change the larger features of surface relief. Their effect is seen chiefly upon the minor topography, as a smoothing of

saliencies, the rubbing of ridges into drumlinoid forms, and depositing of drift in the valleys. In general they have had a subduing effect, a smoothing-down and levelling-up action. The greatest effect of these forces was doubtless felt along the north-facing slope, or over the northern quarter of the area. The series of east-and-west escarpments which probably once existed here have been so destroyed that only a few traces remain. The greater glacial lakes were also restricted to this lower ground, and they have completed the levelling process.

In Pre-Glacial time, as now, the region was low upon the north, and the Hamilton and Portage-Chemung terranes formed a high plateau in the central and southern belts. It seems sure that the present northward drainage is following in general its Pre-Glacial direction, save that over the low northern plain the channels of stream-flow are all new.

The chief problem of the ancient drainage relates to that south of the present east-and-west divide. This water-parting between Laurentian and south-flowing waters is probably of glacial origin, due to morainal filling of old valleys. A partial study of the problem leads to the belief that the entire area of Western New York, with considerable territory of Northern Pennsylvania, was originally drained to the northward. The Genesee river system, flowing north entirely across the State, is suggestive of the Pre-Glacial condition of river-flow. In this connection it should be noted that the crustal warping of the region has been a relative uplift to the northward in Post-Glacial time, which has discouraged the northward flow.[1]

Ice Invasion.

Directions of Flow.

Of the direction of ice-movement during the period of advance and culmination of the glacial sheet, little evidence has been collected in this region. The trend of the terminal moraine, making a re-entrant and nearly right angle at Salamanca, indicates a general movement from the north-east, with a movement from the north-west along the basin of Lake Erie.[2]

The directions of movement of the waning ice-sheet are abundantly shown by striæ and drumlin ridges. The only portion of the area where the later ice-flow was from north-east to south-west, in general, is in the district between the Genesee and Niagara rivers. East of the Genesee the movement was south and east of south. Over this district the ice seems to have been compelled to flow in the direction of the deep valleys now holding the "Finger" lakes. In the south-west portion of the State the movement was away from the Lake Erie basin, or toward the south-east.

The comparatively abrupt change in direction in the neighbourhood of Rochester is noteworthy. The direction of striæ at Rochester is

[1] A map showing the directions of drainage and the water-partings may be found in Bull. Geol. Soc. Amer., vol. vi, pl. xviii.

[2] See papers by Professor T. C. Chamberlin in the 3rd and 6th Annual Reports of the United States Geological Survey.

S. 45–60 W., and the drumlins are generally pointing south-west. Ten miles east of Rochester the drumlins are due north and south, and further away they veer to east of south. The depression of Irondequoit bay and valley is the dividing-line.

At the last recessional phase the ice over Rochester was given a southward and spreading movement, due probably to a re-entrant angle in the ice-body over the Irondequoit depression, where the ice was more rapidly removed by the deep glacial waters. This produced the crescentric moraine with which the Pinnacle Hills are correlated.[1]

Thickness of Ice-cap.

If we locate the margin of the ice-sheet at the terminal moraine, and assume the average slope of the surface to be 30 feet per mile for over 100 miles from the margin, the elevation of the ice-surface above tide-level is estimated as follows: over the eastern end of Lake Erie, 2,800 feet; at Buffalo, 3,000 feet; at Rochester, 4,000 feet; at the centre of Lake Ontario, 5,000 feet; at Syracuse, 5,500 feet; over the middle of Seneca Lake, 4,200 feet.

The thickness of the ice over the same localities is estimated, taking account of land altitude, and making allowance of three feet per mile for north-eastward differential uplift, as follows: over the eastern end of Lake Erie, 2,300 feet; at Buffalo, 2,400 feet; at Rochester, 3,700 feet; at the centre of Lake Ontario, 5,700 feet; at Syracuse, 5,400 feet; over the middle of Seneca Lake, 4,600 feet.

Glacial Deposits.

General Drift Sheet.

On account of the variety, in kind and resistance, of the subjacent rock strata, the Glacial Drift is very variable in both amount and composition. It is usually thin upon the outcrop of hard strata, and in any locality consists largely of material derived from rocks lying immediately northward. For the bulk of material the distance of transportation is not great.

Drumlins.

This area includes some most remarkable groups of drumlins. Over some districts the great bulk of drift seems to be gathered into drumlin forms. The district between Rochester and Syracuse is especially noticeable, as here the drumlins are more conspicuous, rising abruptly from a level silt plain. In some places the drumlins coalesce into great and elevated masses, as for example the "Turk Hill" group, 12 miles south-east of Rochester. The typical form of the region is not the short, mound-like or ovoid form, although these are present, but much elongated or attenuated forms. A length of one mile is common. They seem to have the boldest forms and are more typical where containing more adhesive or clayey material, as along the belt of soft Salina shales. They are strangely wanting

[1] H. L. Fairchild, "The Kame Moraine at Rochester, New York": American Geologist, vol. xvi, pp. 39-51.

over large districts. Their direction, that of the ice-flow, has been referred to above. It is believed that they are subglacial constructional forms, a modification and localization of the ground-moraine. Every gradation can be found from a slight parallel ridging of the general drift surface (finely shown along the Rome, Watertown, and Ogdensburg Railroad, between Rochester and Niagara) to the bold isolated mound. Between the typical, strong, well-developed ridges (as in the neighbourhood of Clyde), there may often be found another set of minor ridges, as distinct as the great ridges, but perhaps of only a comparatively few feet in height and breadth.

Moraines.

The terminal moraine barely enters the southern edge of the State, at Olean and Salamanca, in a re-entrant angle. This line of drift is mapped in all large treatises and textbooks. The greatest development of morainal drift in the eastern half of our area fills the heads or southern ends of the valleys of the lake region, making an irregular and curving belt. This has been well illustrated by Professor Chamberlin.[1] In the larger north and south valleys of the "Finger" lake region, the moraine is usually an enormous drift mass of characteristic topography which blocks the valley and establishes the water-parting. Upon the high intervening ridges the moraine is inconspicuous or quite wanting. It seems evident that in the lake district the ice-field was, during recession, divided into practically distinct valley glaciers.

In the western and south-western portion of the area the moraines are more numerous and irregular lines. Two systems exist: one north-east and south-west, parallel with Lake Erie, in the south-west corner of the State; the other somewhat parallel with the Ontario shore, in the north-west corner of the State. These have been mapped by Mr. Frank Leverett.[2]

In the districts of well-developed drumlins morainal drift is almost wanting, but large kame areas suggest pauses of the ice-front. It would appear that the forces producing drumlins and moraines have not both been fully effective in the same locality. They seem in some degree mutually exclusive.

Glacio-Aqueous Deposits.

Eskers.

These linear masses of gravel and sand, deposited in the beds of overloaded subglacial streams, are not common. Those seen lie in the bottom of valleys. A very large one, though not of great length, is situated in the Irondequoit valley, near Pittsford.[3] Other well-defined eskers have been seen by the writer between Palmyra and Marion, Wayne Co.; near Gorham, Ontario Co.; in Henrietta Town,

[1] "Terminal Moraine of the Second Glacial Epoch": 3rd Annual Report, U.S. Geol. Surv., pp. 291–492. Plate xxxiii covers the area of Western New York.

[2] Amer. Journ. Sci., vol. L, pp. 1–20.

[3] See Journal of Geology, vol. iv, p. 135.

Monroe Co. With fuller observation the list will doubtless be much extended. However, it would seem that the glacial streams in this area were seldom overloaded, although the large kame areas prove that they carried heavy burdens.

Kames.

While eskers are rare, kames are abundant, and some of immense development. This might be expected; for, if the glacial streams did not leave their loads in their channels, they must have dropped them at their debouchure.

In the great amount of sand and gravel, especially abundant and widespread north of the water-parting, it is hard to discriminate between true kame and other forms of water-laid drift, and no complete study has been made. A few of the very large and conspicuous kame areas have been briefly described by the writer.[1]

These large deposits all lie in the basins of glacial lakes, and it is suggested as a working hypothesis that true kames are formed only in static waters.

Glacial Lakes.

Primitive and Smaller Local Lakes.

As the ice-front crept slowly backward from the water-parting which its morainal drift had established, hundreds of lakelets were produced between the ice-foot and the northward-facing land-slopes. Most of these were evanescent, and have left slight traces. Others at the heads of well-defined valleys enlarged with the ice retreat, and existed long enough to produce definite outlet channels and the characteristic phenomena of static waters, excepting beaches, which require great breadth and depth of water.

Larger Local Lakes.

The large north-sloping valleys were the loci of greater glacial lakes. The life-history of these waters is often complicated and always fascinating. Each of the lakes in Western New York has been preceded by a vastly larger and deeper lake having its outlet to the southward. Large glacial lakes also existed in some valleys in which no water is ponded to-day. Some of these lakes have already been described.[2]

The most complicated and interesting lake-history belongs to the Genesee valley,[3] in which not less than ten stages of the glacial waters can be recognized. These waters flowed alternately east or west, according as the ice-sheet uncovered lower passes, and at different times they contributed to the Ohio-Mississippi, to the Susquehanna, to the Lake Michigan-Mississippi, and to the Mohawk-Hudson.

[1] H. L. Fairchild, "Kame Areas in Western New York, South of Irondequoit and Sodus Bays": Journal of Geology, vol. iv, pp. 129–159. "Kame Moraine at Rochester, New York": Amer. Geol., vol. xvi, pp. 39–51.

[2] H. L. Fairchild, "Glacial Lakes of Western New York": Bull. Geol. Soc. Amer., vol. vi, pp. 353–74.

[3] "Glacial Genesee Lakes": Bull. Geol. Soc. Amer., vol. vii, pp. 423–52.

Pre-Laurentian Lakes.[1]

Lake Warren.—The area of Western New York is involved in only the later phases of the Laurentian glacial lake-history. The first of these glacial waters that invaded our area were those of Lake Warren. The beaches of this great lake have been traced about the southern shore of Lake Erie and through Western New York to beyond the meridian of Rochester,[2] with an elevation of 883 feet at the northernmost point.

The Warren waters were drained to a lower level by the ice-front receding in the vicinity of Syracuse sufficiently to uncover land that permitted flow to the Mohawk-Hudson, at a level below that of the former outlet across Michigan to Lake Chicago and the Mississippi.

Lake (unnamed; Geneva Beach).[3]—A well-defined beach, lying at an elevation of about 700 feet, has been traced for 30 miles along the western side of the Seneca lake valley and westward to Shortsville, while evidences of the same static water have been noted farther west. It is supposed that these phenomena belong to a long pause in the irregular fall of the Laurentian glacial waters from the Warren level to the Iroquois level; but the outlet correlating with the level is unknown.

Lake Iroquois.—This latest glacial water in the region has left the strong, mature shoreline about the Ontario basin, correlating with the ancient channel at Rome, N.Y., opening into the Mohawk.[4] The phenomena are strong, and the main facts in the history are clear. The beaches, like those of the preceding waters, show a decided northward uplift, amounting to five feet per mile between Syracuse and Watertown.

Morainal Lakes.

Doubtless many lakes had a brief existence, due to morainal dams, but only a few have been identified, these lying in the valley of the Genesee river. A brief description may be found in a former paper.[5] These were drained by the cutting of rock gorges (see last section of this paper). The largest of these morainal lakes was above Portageville. Another was in the new valley of the river above Mount Morris. Others occupied side or tributary valleys to the Genesee.

[1] For the latest comprehensive statement of the lake-history in the Laurentian basin as a whole, see article by F. B. Taylor, "X. A Short History of the Great Lakes," in 'Studies in Indiana Geography,' edited by C. R. Dryer. Terre Haute, Indiana, 1897.

[2] H. L. Fairchild, "Lake Warren Shorelines in Western New York and the Geneva Beach": Bull. Geol. Soc. Amer., vol. viii, pp. 269–86.

[3] Ibid., pp. 281–4.

[4] G. K. Gilbert, "The History of the Niagara River": 6th Ann. Rep. Com. of State Reserv. at Niagara. Albany, 1890.

[5] H. L. Fairchild, "Glacial Genesee Lakes": Bull. Geol. Soc. Amer., vol. vii, pp. 449–52.

Channels of Glacial Drainage.

A considerable number of the outlet channels of the larger local glacial lakes have been studied and partly described in the papers to which reference has been made. No outlet of the great pre-Laurentian lakes lies within this area, the Iroquois outlet being to the east. The area does contain, however, the channels which drained the Warren waters down to the Iroquois level, a fall of over 400 feet. These lay along the receding ice-front in the Rochester-Syracuse region. Some were rock channels of considerable duration, while others were shifting channels closely following the glacier foot. These have been studied by Mr. Gilbert, but only a brief notice published.[1]

Post-Glacial Stream Erosion.

The great majority of streams on the low northern plain meander in drift channels, rarely touching the rock, and have done little work of corrasion. The heavier streams have in a few cases done considerable rock-cutting. Of similar age and character to Niagara gorge is the ravine of the Genesee at Rochester, but of less dimensions. This cutting, with that of Oak Orchard Creek, Irondequoit Creek, Seneca River, and all other minor ravines and falls on the northward slopes, at an altitude less than 800 to 880 feet, are subsequent to the time of Lake Warren. Those at an altitude of less than about 400 feet are subsequent to Lake Iroquois. The Genesee ravine at Rochester is mostly post-Iroquois. The fine ravines at Mount Morris and Portage began much earlier, during the Lake Warren episode, as outlets of morainal lakes.

DESCRIPTION OF THE MAP (PLATE XXI).

Numerals.—The figures give elevations, in feet, above mean ocean-level. At cities and towns, reference is to top of rail at the principal railway station.

Divides, Water-Partings.—These are indicated by the heavy broken lines. Cols which are known to have been outlets for glacial lakes are indicated by bars placed transverse to the line of water-parting. The figures giving the elevation of such cols are also placed transverse.

Moraines.—The morainal belts have not been traced east of the Genesee river, and cannot exist there in so good form as in the area west of the Genesee. Throughout the region of the "Finger Lakes" the morainal drift is chiefly massed in the deep north and south valleys, as indicated. North of those lakes the drift was deposited in the presence of deep glacial waters, and morainal lines are scarcely traceable.

The terminal moraine, past the cities of Olean and Salamanca, is not as definite a belt as the map would suggest.

Kame Areas.—A few well-known areas of heavy water-laid drift are indicated south of the two great bays in the south shore of Lake Ontario, but other areas exist, notably in the Genesee valley, and associated with the larger moraines. South of the great divide the valleys are deeply filled with the detrital overwash from the glacial floods.

Drumlins.—The areas of drumlins are only very roughly suggested. The orientation of the drumlin axes is better indicated.

Glacial Lake Shorelines.—Three shorelines are indicated: the lowest, Iroquois, with an average elevation in the Finger Lake region of 440 feet; the

[1] G. K. Gilbert, "Old Tracks of Erian Drainage in Western New York": Bull. Geol. Soc. Amer., vol. viii, pp. 285-6.

Geneva beach, 700 feet: and the Warren shoreline, about 880 feet. Another and still higher shoreline exists in at least the Seneca and Cayuga valleys, but is not indicated on the map, as its east and west limits are not yet determined. This is the shore of Lake Newberry, having its outlet south of the present Seneca, by the 900 feet col—the Horseheads Channel.

The Iroquois shoreline is represented as continuous, although from Sodus Bay eastward it is broken and indeterminate.

The waters producing the Geneva beach certainly occupied a large area, but as so little is at present known of that lake, the shoreline is represented only along the west side of Seneca valley, where it has been continuously traced.

The Warren shoreline has been continuously traced eastward to beyond the meridian of Rochester, and good spits and bars have been found in the Cayuga valley. The theoretical limits are indicated as far east as the first spillway of the lowering waters.

II.—Do the Crystalline Gneisses represent portions of the Original Earth's Crust?

Presidential Address read before the Liverpool Geol. Soc., October 12, 1897.

By Joseph Lomas, A.R.C.S., F.G.S., Pres. Liverpool Geol. Soc.

IN order that progress may be made in any branch of geology, it is necessary, not only that the faculties of observation and inductive reasoning should be employed, but a proper use should be made of the imagination. By this means new lines of research are laid out. The theory we set ourselves to prove may eventually prove to be wrong, but it often happens that the pursuit of a false theory brings one as near the truth as the following up of a true one. It is in this spirit I wish you to regard the problems and speculations to which I now invite your attention.

The oldest rocks with which we are acquainted are the crystalline gneisses and schists which form the lowest divisions of the Archæan. Geologists are far from being in accord as to their origin. Some regard them as altered sedimentary rocks, metamorphosed to such a degree, that they have been fused to form igneous rocks anew; and whilst they were in a fluid or semi-fluid condition, at a great depth below the earth's surface, they received the characters of foliation and schistosity which most of them show. Others regard them as igneous rocks which have been altered by flow and shear. Others, again, prefer to look upon them as remnants of the crust of the earth when it first consolidated from the liquid state.

They are the only rocks which can be regarded as forming a continuous shell round the earth. On them, as a foundation, all the later formations have been deposited.

Professor Lapparent[1] refers to the remarkable uniformity of these primitive rocks. In Brittany, the Pyrenees, Alsace, Bavaria, the Alps, Saxony, Scandinavia, Great Britain, Spain, Algeria, North America, Brazil, and China, and wherever they are found, the same succession can be made out—gneissose or granitoid at the base and schistose above. Chemically they are very much alike, except that alkalies predominate in the gneissose rocks, and calcareous material in the schistose. He regards them as having been produced on the

[1] "Traité de Géologie," p. 675.

solidification by cooling of the earth; and as having been formed in a sea of high temperature, charged with chemically active substances and subject to the frequent intervention of adjacent liquid magmas.

The continuity of these ancient rocks and their persistent characters certainly point to a cause of origin which was world-wide in its effects rather than local. The main difficulty is to find a worldwide cause which could produce the foliation so characteristic of these rocks in all parts of the globe.

Modern researches show that gneissose and schistose structures can be induced either by fluxion or shearing, or by both combined.

The ancient gneisses are usually found as low hummocky hills; when sufficiently denuded a core of granitoid rock is seen, and the foliations of the flanking parts are parallel to the axes of the ridges. Sir A. Geikie[1] remarks on the similarity of scenery which these rocks show in places where they crop out. A person situated in the central part of Anglesey might very well, so far as the landscape is concerned, imagine himself in the wilds of Sutherlandshire.

Professor G. H. Darwin[2] has demonstrated that in early times the moon was thrown off from the earth, and while it was still in proximity to the parent planet great tidal waves would result from its journey round the earth. The plane of the moon's orbit being but little removed from the earth's equator, the retardation of the diurnal motion of the earth, due to tidal friction, would be greater at the equator than at the poles. "Now, this sort of motion, acting on a mass which is not perfectly homogeneous, would raise wrinkles on the surface. . . . . In the case of the earth the wrinkles would run north and south at the equator, and would bear away to the eastward in northerly and southerly latitudes. . . . . The general configuration of the continents (the large wrinkles) on the earth's surface appears to me remarkable when viewed in connection with these results."[3] These conclusions of Professor Darwin were arrived at altogether independently of geological reasoning, and it may be worth while to consider whether we have any geological evidence to support his theory.

The result of the moon's action on the earth in early times, then, would be a screwing or twisting of the surface layers. This raised them into wrinkles or ridges north and south at the equator, and partaking more and more of an easterly direction as we approach the poles. It is probable that at this time the earth was in a highly heated condition, and thus flow and shear of the surface parts over the lower would combine to produce the wrinkles. Probably the wrinkles were formed very slowly, by the gradual accretion of small stresses acting over long periods, in a manner so well illustrated by our ex-President when speaking of the flow of rocks by alternate expansion and contraction.[4]

[1] "Ancient Volcanoes." [2] Phil. Trans. 1879, p. 589.

[3] Ibid. Also read in this connection, chap. ix, "Physics of the Earth's Crust," O. Fisher.

[4] "Origin of Mountain Ranges," by T. Mellard Reade; see also GEOL. MAG. 1894, pp. 203–14.

Sir A. Geikie, in opposing the view that the fundamental gneisses and schists represent portions of the earliest crust that consolidated on the surface of the globe, says:[1] "The coarsely crystalline condition, even of those portions of the gneiss which seem most nearly to represent original structure, the absence of anything like scoriæ or fragmental bands of any kind, and the resemblances which may be traced between parts of the gneiss and intrusive bosses of igneous rock, compel us to seek the nearest analogies to the original gneiss in the deep-seated masses of eruptive material." I may remark that a coarsely crystalline condition is a measure of the rate of cooling of an igneous mass rather than of its depth below the surface.

Professor Bonney says:[2] "The crust itself must have solidified under conditions materially different from those of a lava stream at the present day; for not only is crystallization affected by pressure, but also radiation would then be comparatively slow, because the atmosphere would differ much less in temperature from the solidifying rock than the air now does from the surface of a lava stream. . . . . The weight of the atmosphere would be augmented by that of a shell of water of the area of the globe and two miles in thickness; or, in other words, the atmospheric pressure would be then about 350 times its present amount."

Another objection has been raised by Mr. T. M. Reade:[3] "The evidence that the Archæan rocks the world over have been buried under immense bodies of sediment, of which they may have formed the lower series before the deposition of the Palæozoics upon them, then, seems to be irresistible." In answer to Mr. Reade I may say that it would be most remarkable if every trace of these "immense bodies of sediment" had been removed before the earliest sedimentary rock now found was deposited. Undoubtedly there were sedimentary rocks earlier than the Cambrian, such as the Torridonian and Longmyndian, but wherever they are found they lie unconformably on the gneisses and contain fragments of the fundamental rocks, which show foliation. Foliation, then, could not be the result of overlying sediments, as the structure was developed before the oldest sedimentary rocks with which we are acquainted were laid down. I hope to point out later, that there is evidence to show that some of these gneisses have never been covered at any period of the earth's history.

According to Professor Darwin the primitive wrinkles would trend about N.E.–S.W. in our latitude. The ancient gneisses of Wales, Scotland, and Scandinavia, all have a strike about N.E.–S.W. Comparative geology is as yet in its infancy, and information regarding some of the places where Archæan rocks are exposed is not easily obtained. So far as I have been able to glean information on the point, I have not found an instance which is not in accord

[1] "Ancient Volcanoes," p. 116.
[2] "Story of our Planet," p. 341.
[3] "Origin of Mountain Ranges," p. 150.

with the above theory.[1] Some of the ridges would probably be of continental importance, but with smaller corrugations riding on them.

We will suppose now that the earth's crust has become solid, and the wrinkles remain as long parallel ridges and hollows. It is inconceivable that they should ever unfold again. They might rise or fall as parts of greater movements, or their symmetry and continuity might be destroyed by other foldings not parallel with themselves, but otherwise they could only become degraded by the forces of denudation. We must look upon these primitive ridges, aided to a certain extent by volcanic material which has welled up through the crust in later times, as the source of all the sedimentary rocks. The crests have become denuded, and the products of disintegration have been transported by various agents and laid down on the floors of the troughs. The material of the oldest sedimentaries must have been derived from the highest parts of the ridges, and that forming the newer sedimentaries must have been furnished by the deeper parts of the ridges. This rule, of course, only applies so long as deposition continues (in Wales practically to the end of the Silurian). If the sea-bottom becomes raised to form land, then the sedimentary rocks themselves become denuded, and the tracing of a particle to its ultimate source becomes a complex problem.

If the picture drawn above of the relief of the land in early times be true, the oldest sedimentary rocks should attest the fact by their characters and distribution. Professor G. M. Dawson, speaking of the Archæan sedimentary rocks of Canada, says:[2] "We find long bands of strata, referable to the Huronian and Grenville Series, occupying *synclinal troughs*, more or less parallel to each other and to the foliation of the Fundamental Gneiss, the strata, as well as the foliation, being in most cases at high angles, vertical, or even reversed." Many other instances might be quoted from America, where the sedimentary rocks of Pre-Cambrian age are described as being laid down in long parallel troughs with sides composed of Fundamental Gneiss. In Europe "the oldest beds of Bohemia form a *basin* some 90 m. long and 10–12 m. broad, the principal axis running in a south-west direction from Prague through Beraun to Pilsen. In consequence of this very regular structure, the oldest beds occur at the boundary and the newest in the middle of the basin, whilst the floor of the trough is made up of Archæan rocks, and, above them, of unfossiliferous, phyllitic schists, called the Przibram schists by Lipold, which include locally conglomerate, sandstone, and oolitic limestone."[3]

In Britain the same story is told. The Archæan rocks of Anglesey and the Lleyn Peninsula, and those of the Midlands, form ridges about N.E.–S.W., which bound a trough in which are contained the Cambrian and Silurian deposits. Further west the folds are repeated in the N.W. Highlands, and eastwards, under the capping of newer rocks, into Normandy, Scandinavia, etc.

[1] Mr. R. Gascoyne, who has just returned from Chili, informs me that the strike of the Archæans in that country is about N. and S.

[2] President's Address, Section C (Geology), British Association, 1897.

[3] Kayser-Lake, "Text Book of Comparative Geology," p. 39.

The characters of the oldest sedimentary rocks lend aid to the theory that they were laid down in long, parallel trough-like depressions. Dr. Hicks, speaking of the Lower Cambrian, says:[1] "The deposits must have accumulated with comparative rapidity in fairly shallow water." Shallow-water deposits imply proximity to land. We cannot obtain shallow-water rocks, extending as they do in separate troughs from Britain to Russia, on the assumption that they were laid down in a continuous sea extending across Europe. Dr. Hicks many years ago propounded this theory to account for the distribution of the Cambrian rocks.[2]

It is probable that the primitive ridges were not very lofty. They would, no doubt, form the counterparts of the troughs. Professor Lapworth has shown[3] how persistently a lofty fold is counterbalanced by a deep parallel depression, and a low ridge by a shallow trough. Dr. Hicks suggests[4] that high mountains existed in Pre-Cambrian times, and that some of them were probably snow-covered. So far as I can gather, the only reason why he postulates these high mountains is to explain the occurrence in the Cambrian conglomerates of boulders over a foot in diameter. In mountain-building, as in everything else about us, there has been a gradual evolution going on. The Tertiary is the epoch of mountain-building, and there has probably been a progression in the heights of mountains from ancient to modern times.

The tracing out of old shorelines, and the mapping of former distribution of land and water, form a branch of geology which has of late come into prominence.

Pioneer work has been done by Godwin-Austen, Professor Hull,[5] Jukes-Browne,[6] and others, but much will need to be done before we can draw maps which will show the distribution of land and water in Palæozoic times with accuracy. The maps published by Professor Hull and Jukes-Browne must not be taken as being absolutely correct, especially in the Palæozoic period. We may, however, regard them as approximations to the truth. I had occasion recently to copy out on tracing-paper the Palæozoic shorelines as given by Jukes-Browne. On accurately registering these and holding them up to the light, I was struck with the fact that in some districts there was a great closing up of shorelines. This was especially noticeable about Anglesey, where within a few miles of each other the Cambrian, Ordovician, Silurian, Carboniferous, and Permian shorelines are found. It would seem as though in Anglesey we were dealing with a very stable part of the earth's crust, a part which had kept its position relatively to the sea nearly the same through long ages. As there is every reason to

[1] President's Address, Geological Society, 1897.
[2] Q.J.G.S. 1875, p. 552.
[3] President's Address, Section C, British Association, 1892.
[4] Geological Magazine, 1876, p. 157.
[5] "Contributions to the Physical History of the British Isles."
[6] "The Building of the British Isles."

believe that Anglesey kept its head above water during the Mesozoic and Cainozoic Periods, it follows that portions of the Archæan rocks on the north-west of the island have never been submerged at all.

A second aggregation of shorelines is seen in the Midlands, closely following the Archæan ridge. This is not so striking an example as that in Anglesey, but it is sufficient to suggest that the solid cores of the primitive wrinkles have resisted great lateral crushings, while the sedimentary rocks deposited in the troughs have been crushed, folded, and cleaved to a great degree. We might almost compare the ridges to nodes in the great wave-like motions which have swayed the surface rocks up and down like long ocean swells.

In order to bring the arguments given above into better view, I may summarize the chief points touched upon.

1. The worldwide distribution of the fundamental gneisses and schists and their uniformity of characters suggest a cause which affected the world as a whole.
2. Professor Darwin has shown, altogether apart from geological reasoning, that primitive wrinkles would be formed on the crust by the action of the moon when nearer the earth. So far as I have been able to gather, the ridges formed by the oldest rocks now existing correspond in direction with the wrinkles Professor Darwin describes.
3. The lithological characters of the primitive rocks are such as would result from the flowing and shearing of rocks (in which crystals had already formed but were in a highly heated condition), on being raised into wrinkles by differential movements.
4. The earliest sedimentary rocks were deposited in long troughs, parallel to each other for the same latitude.
5. The ridges themselves never unfolded. Some of them have remained at approximately the same level through all time, and others have partaken of greater movements in later times. The continuity of the ridges has been destroyed in some places by later foldings not parallel to themselves.

And now, in conclusion, may I refer to a matter which arises directly out of the subject-matter of the Address? In many text-books, and even in geological papers, the young student is told in effect that "every part of the earth has been raised and depressed times without number." As our knowledge increases I believe that this loose and offhand method of dealing with earth-movements will give place to more precise and definite statements. It will then be found that changes of level have not taken place promiscuously, but according to certain laws, of which we have at present only the foreshadowing. I do not refer so much in this matter to local movements, which can be traced to obvious local causes, but rather to those extending over great areas. A large movement must have a deep-seated cause, which will leave permanent witness to its operation.

All branches of science must necessarily pass through three stages—(1) the observation of facts; (2) the enunciation of theories to explain the facts; (3) the discovery of laws governing all. In geology many facts have been gleaned, many theories have been launched, and of these precious argosies, only the seaworthy, those built in conformity with natural laws, will arrive in port.

III.—On *Ceratodus Kannemeyeri* (Seeley).

By H. G. Seeley, F.R.S., Professor of Geology in King's College, London.

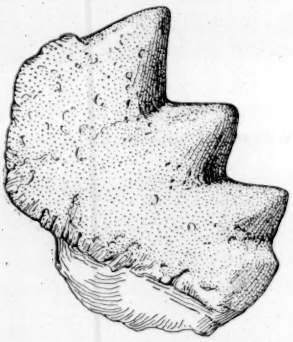
DR. DANIEL RUSSOUW KANNEMEYER sent me a photograph of a dental plate in April, 1897, to which was appended the remark—"I conclude it to be *Ceratodus*, and its bones are said to be lying at Kraai Fontein. I have sent the man who found it to search for and fix the locality." The search was not successful; and since then the rinderpest has prevented any attempt to reach the locality, which is geologically at the top of the Karoo beds above the Coal of the Indwe district of Cape Colony, in strata which yield Zanclodont reptiles in other localities. It may therefore be classed as of Triassic age, belonging to the Stormberg Series, and well above the Permian rocks which have yielded Theriodonts. This determination is of some interest as contributing to define, by means of a well-marked Trias genus, the age of the upper limit in South Africa of strata which have yielded Theriodont and Dicynodont reptiles. Such a division between Trias and Permian agrees with the grouping of the rocks to which I was led by a physical examination of the country in 1889.

Failing for the time to obtain the other reputed remains, Dr. Kannemeyer has recently sent me the tooth, which differs as a species from all known types. In 1889 Mr. A. S. Woodward (Ann. and Mag. Nat. Hist., Sept., p. 243) mentioned and figured a small example of a tooth of *Ceratodus*, found at Smithfield in the Orange Free State, which he named *Ceratodus Capensis*. It is distinguished from the new form, which I associate with the name of Dr. Kannemeyer, by the narrow rounded ridges which diverge over the dental plate, as well as by the relatively broader form of the plate, and by its thinness; and *C. Capensis* differs from the common forms of the Muschelkalk and Rhætic beds of Europe by such characters as separate it from the new African species (see Figure).

The left superior dental plate of *Ceratodus Kannemeyeri* is thick and flat, with a nearly vertical serrated external border made up of three strong wedge-shaped denticles, with a slight convexity in front and a marked convexity behind them. The plate has a thick base, which is prolonged backward in a way seen in some species from the Trias of Germany, but the base does not extend to the inner anterior border of the dental plate, which may possibly be a line of union with the corresponding plate on the opposite side of the palate.

The specimen measures 4·5 cm. from front to back. The extreme transverse width over the first denticle is 3·5 cm., while over the

third or hindermost denticle the width is 2·1 cm., exclusive of the base; but including the base, the transverse hinder measurement is 3·1 cm. The three wedges which form the external margin diminish in size successively from front to back. The notch between the first two is almost exactly a right angle, and the notch between the second and third is rather less than a right angle. The thickness of the dental plate, including the base, is 1·8 cm., but above the base



Left Dental Plate of *Ceratodus Kannemeyeri*. Natural size.

it is about 1·3 cm. thick. The sides of the notches which define the denticles are flat, smooth, and so formed that the notch extends a little inward as it meets the nearly horizontal crushing surface; and the flat sides converge outward to form the sharp external angles of the wedges, which round convexly along the crest of each on to the flat surface of the plate.

The tubuli of the dental plate are vertical in all parts of the tooth, and are arranged in linear series, so that they form labyrinthic patterns, which have a general extension in the longitudinal axis of the tooth and extend transversely across the three external denticles, but are parallel to the external margin of the posterior rounded convexity, which is rather more elevated than other parts of the tooth. It is probable that this pattern is exposed by removal of the enamel.

The fossil resembles *C. Guilielmi* (Plien), from the Muschelkalk of Hoheneck, in form of the dental plate and its flatness, and in character of the denticles; but differs in having only three denticulations, with terminal convexities back and front. It also may be compared with *C. Hislopianus* from the Gondwana beds of Nagpur, in the thickness of the dental plate, which involves some resemblance in the denticles; but in that Indian species there are five denticles instead of three, and the plate is relatively narrower. There is no species with a similar broad flat crushing surface, and three thick wedge-shaped denticles, which decrease in size from front to back.

IV.—On a Method of Determining the Actual Direction of Movement, whether Lateral or Vertical, in Faults.

By Philip Lake, M.A., F.G.S.

In calculating the throw of a fault, it is usual to assume that the whole of the displacement due to the fault has been produced by a vertical motion—i.e. by a motion in a vertical plane at right angles to the direction or strike of the fault—and that there has been no such thing as a lateral movement of one face of the fault upon the other.

Suppose, for example, that in Fig. 1 the plane of the paper is the plane of the fault, that the heavy line A B represents the outcrop or "trace" of a bed upon one of the faces of the fault, and the light line A′ B′ the outcrop or "trace" of the same bed upon the other face, the horizontal line being the surface of the ground. It is almost universally supposed (in practice at least) that before the formation of the fault the point A was in coincidence with the point A′ (which is now vertically below it), and the point B with the point B′; and that the line A A′ or B B′ shows both the direction and amount of the movement.

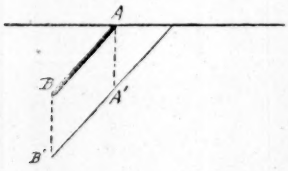


Fig. 1.

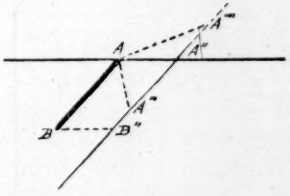


Fig. 2.

But this may not be true. It is possible that A may have coincided with A″ (Fig. 2) and B with B″; the movement may have taken place along the lines A A″, B B″, or, in other words, may have been entirely lateral or horizontal. Or the point A may have coincided with some other point A‴ or A⁗; and in that case the movement must have taken place along the line A A‴ or A A⁗, and must have been partly horizontal and partly vertical. Yet the result is apparently the same; and it is impossible, therefore, in such a case, to determine the actual direction of the movement. When, however, the fault crosses an anticlinal or a synclinal, the effects of lateral, as opposed to vertical, motion are sometimes so clear that they have already attracted attention.

Most of the textbooks explain the effect of a fault upon an anticlinal on the assumption that the movement has been purely vertical. They show, if the ground be level, that the two outcrops of a bed on the downthrow side of the fault will lie closer together than the two outcrops on the upthrow side; and they show, moreover, that if the outcrops on the downthrow side be produced across the fault

they will lie between the outcrops on the upthrow side (Fig. 3). A little consideration will make it clear that the position of the anticlinal axis upon the map is entirely unaffected by such a fault, because it has simply been shifted vertically. If, however, the movement of the one face of the fault upon the other has been horizontal instead of vertical, the whole anticlinal will have been thrown to one side; and the outcrops on one side of the fault will no longer, if produced, lie between the outcrops on the other side (Fig. 4).[1]

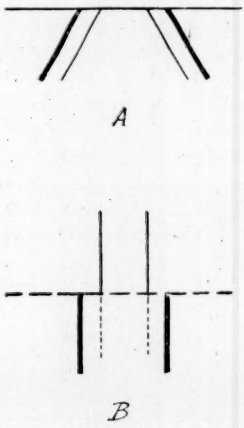


Fig. 3.

Anticlinal faulted by a fault, the movement along which has been vertical.

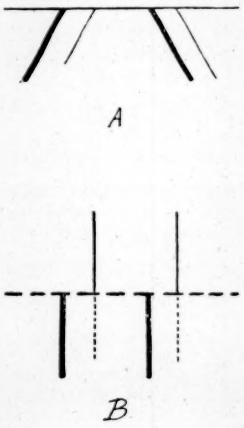


Fig. 4.

Anticlinal faulted by a fault, the movement along which has been horizontal.

A shows the two faces of the fault, as in Figs. 1 and 2. *B* Plan.

Cases of this kind are by no means rare, and must have led many geologists to reflect that no amount of vertical movement can account for them. Between Aber and Bethesda, for example, there is an anticlinal of Lingula Grits crossed by a series of parallel faults. Most of the faults produce no effect upon the axis of the anticlinal, but the one on Ffridd-du shifts the whole anticlinal several hundreds of yards to one side.[2] More striking still is the fact that during one or two recent earthquakes visible faults have been formed accompanied by a lateral displacement of the ground on one side of the fault.[3]

[1] The converse case of a synclinal is so similar that it is unnecessary to refer to it here.

[2] See Quarter-sheet 78 S.E. of the Geological Survey of England and Wales. A map of the area is also given in "The Geology of North Wales" (Mem. Geol. Surv., vol. iii), 2nd ed., p. 202.

[3] See, for example, "Notes on the Earthquake in Báluchistán on the 20th December, 1892," by C. L. Griesbach: Rec. Geol. Surv. India, vol. xxvi (1893), pp. 57–61, 3 plates. The chief evidence of lateral displacement is the disturbance of

It is certain, therefore, that in some cases an actual, and not merely an apparent, lateral displacement has occurred during the formation of a fault. But so far as I am aware, no one has yet shown how to determine the real direction of the movement and the inclination of this direction to the horizontal. If all the beds affected by a fault dip at the same angle and in the same direction, the problem is indeed insoluble. But if the dip be not uniform, if the beds be in any way bent or folded, the solution is theoretically easy.

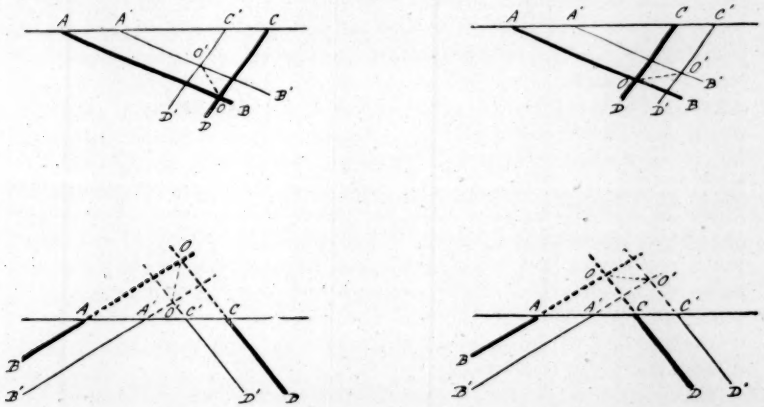


Fig. 5.

Method of finding true direction of movement.
(The description applies to any of these four diagrams.)

Suppose that in any of the four diagrams in Fig. 5 the plane of the paper is the plane of the fault; that the heavy lines A B, C D represent the outcrops of beds (having different dips) upon one face of the fault; and A′ B′, C′ D′ the outcrops of the same beds upon the other face. Produce A B and C D to meet in O, A′ B′ and C′ D′ to meet in O′. Then the line O O′ lies in the direction in which one face of the fault has moved upon the other, and the length O O′ is the amount of the movement. For the effect of the fault is as if the line A B were moved bodily into the position of the line A′ B′,[1] and the line C D into the position of the line C′ D′. Now the point O is a point in the line A B, and it must therefore

a railway line. This alone, however, would not be conclusive, for railways are but loosely attached to the earth. A similar disturbance of a railway line was produced in the recent Indian earthquake of the 12th June, 1897; but the figure given by Oldham (Rec. Geol. Surv. India, vol. xxx, pl. xvii) seems to show that the sides of the railway track, as indicated by the lines of vegetation, remained undisturbed.

[1] This does not mean that the *point* A is moved to the position A′, or B to B′; but that the line A B (which may be imagined to be indefinitely produced) is moved to the position of the line A′ B′ (also indefinitely produced).

have moved to some position in A′ B′. It is also a point in the line C D, and therefore it must have moved to some position in C′ D′. Consequently the new position of the point must lie both in A′ B′ and in C′ D′, and it must therefore lie at their intersection O′: the effect of the fault has been to move the point O to the position O′, and every point in A B and in C D has moved along a line parallel and equal to O O′.

It may be remarked here that it is impossible to say whether A B or A′ B′ was the original position of the bed, and it is therefore impossible to determine whether the movement took place from O to O′ or from O′ to O.

If the movement has been uniform throughout the area considered, then the solution is perfectly general. A B and C D may or may not be the same bed. The line A C need not be horizontal or even straight. The positions of A and C with respect to each other may be chosen quite arbitrarily. The only conditions to be satisfied are that A A′, A B, A′ B′, C C′, C D, and C′ D′ make the proper angles with the horizontal; and that A A′ and C C′ be drawn according to the particular scale selected. If this be done, then O O′ will also make the proper angle with the horizontal and will be on the same scale as A A′ and C C′. It must be noted, however, that the angles which A B, C D, etc., make with the horizontal, are not the angles of the *true* dips of the beds in question, but the angles of the apparent dips *in the plane of the fault.*

Although the solution is general, there are many faults to which it cannot be applied, even theoretically. If the lines A′ B′ and C′ D′ are not parallel respectively to A B and C D, the problem is insoluble, because the movement has not been uniform. All that we can do is to determine the direction of motion at some particular spot.

As the displacement due to a fault is probably never the same throughout its whole length, it is advisable to take beds A B and C D, which are in actual fact near to each other; and as a general rule there are no cases more favourable for the application of the method than unconformities, where beds of different dips are found one above another.

V.—The Age of the Rand Beds.

By W. Gibson, F.G.S.

In several parts of South Africa, thick sedimentary and unfossiliferous deposits are found resting on gneisses or highly altered rocks. They are well developed in the Southern Transvaal around the towns of Johannesburg and Potchefstroom; in the Northern Transvaal in the districts of Lydenburg and De Kaap, and possibly Zoutspansberg; in Matebeleland, Bechuanaland, Griqualand West, Damaraland, and Zululand. These widely distributed sediments have been generally taken as representing the whole or portions of the sedimentary series typically developed in the Southern Transvaal.

The sequence in the Southern Transvaal is as follows, in descending order:—

1. Gat's Rand Beds, Megaliesberg Beds.
2. Rand Beds.
3. Quartzite and shale group (Hospital Hill Series).

The Gat's Rand series are now considered to be unconformable to the Rand Beds. A dolomite from which Mr. Draper[1] has obtained fossils of doubtful Carboniferous species is associated with the Gat's Rand Beds. It is only the age of the Rand Beds that is here considered.

As investigation is carried on among these rocks, they are found in several areas to be more strongly affected by mechanical movements than any of the rocks newer than the Table Mountain Sandstone of Cape Colony.[2] In the Cape, the folding of the Table Mountain Sandstone and overlying Palæozoic rocks is of Post-Karoo age, the Karoo beds being involved in the folds.[3] Where the Karoo beds exist in the vicinity of the highly inclined and altered Rand Beds, they are nearly horizontal or but slightly inclined. It would therefore seem that the deformation of the Rand Beds is older than the folding of the Palæozoic rocks of Cape Colony.

Another fact in favour of the great age of the Rand Beds is the intrusion into them of basic dykes, which have been converted by pressure into hornblendic and chloritic schists. In the Cape Colony, igneous intrusions, so far as I am aware, are absent from the formations between the base of the Table Mountain and the top of the Zwartebergen Group, while the dykes and sills piercing the Karoo beds are unaltered. Igneous intrusions, in beds older than the Karoo, are confined in Cape Colony to the Malmesbury Schists.

The rocks in Cape Colony that appear to have the closest lithological resemblance to those of the Rand are some slates, grits, and sheared conglomerates found in the Prince Albert Region. These are doubtfully considered by Dr. Corstorphine to overlie the Zwartebergen Quartzites,[4] but as a dolomite is associated with these grits and conglomerates, they would appear to represent the Megaliesberg Group.

Up to the present date the Rand deposits are generally considered to be represented by some portion of the Table Mountain Sandstone series. If so, in the Transvaal there are evidences of a complex series of folds and overthrusts of Pre-Karoo age unrepresented in Cape Colony, except perhaps in the Malmesbury Schists. On the

[1] D. Draper, "The Occurrence of Dolomite in South Africa": Quart. Journ. Geol. Soc., vol. xv, p. 561, 1894.

[2] W. Gibson, "The Geology of the Gold-bearing and Associated Rocks of the Southern Transvaal": Quart. Journ. Geol. Soc., vol. xlviii, pp. 404-37, 1891. W. Gibson, "Geology of the Southern Transvaal": Trans. Fed. Inst., vol. vi, p. 124, 1893. A. R. Sawyer, "Remarks on the Banket Formation at Johannesburg, Transvaal": Trans. Fed. Inst., vol. ix, p. 360.

[3] E. H. L. Schwarz, "First Annual Report of the Geological Commission of the Cape of Good Hope for 1896," p. 28.

[4] Dr. G. S. Corstorphine, "First Annual Report of the Geological Commission of the Cape of Good Hope for 1896," p. 31.

other hand, in Cape Colony and Natal there are evidences of a folding of Post-Karoo age which is not represented in the Transvaal. If a comparison between regions so widely separated as the Southern Transvaal and the Cape be of any value, there seems more probability of the Rand Beds belonging to the Malmesbury Group than to any newer formation.

NOTICES OF MEMOIRS.

I.—The so-called Lode Formations of Hannans, and Telluride Deposits, in Western Australia.[1] By H. P. Woodward, Assoc. M. Inst. C.E., Memb. Inst. M. & M., F.G.S., etc.

HANNANS, as it was originally called, was named after the discoverer, Patrick Hannan, but its name has been recently changed by the Government officials to Kalgoorlie, the native name of a small hill that is situated close to the township. It is about 400 miles from Perth by railway, in the East Coolgardie Goldfield; this field is the smallest, but at the same time it produces the largest quantity of gold of any in the colony. A solid block of country has been taken up upon gold-mining leases, of about 10 miles in length and 2 miles in width, comprising over 700 leases, of which some ten produce almost the entire output of gold of the district.

The great discovery of the district was made at a point about 4 miles south of the township, where a group of mines is being worked which bids fair to equal the richest known mines in the world.

Geology.—The flat surface of the country is covered by a deposit of red loam, beneath which in some places a considerable thickness of blue clay is met with, whilst near the hills it is of only slight thickness. This clay rests directly upon the auriferous series, fragments of which, associated with ironstone and a little quartz, are strewn over the surface, and constitute the dry-blowing patches.

The low range of hills which extends from Kalgoorlie to the Boulder, consists of hard, fine-grained hornblendic schists, intersected by numerous diorite dykes, the whole being capped in many places by deposits of ferruginous claystone.

The rocks, like most of those occurring in Western Australia, do not appear to be of sedimentary origin, but most probably owe their stratified appearance to crystallization under pressure; and they have since been crumpled into a number of anticlinal and synclinal folds, the strike of the axial planes of which is a few degrees west of north.

Lodes.—The lodes or formations, as they are called, are decidedly peculiar, consisting, as they do near the surface, of an indurated mottled ferruginous claystone, which has proved in places to be extremely rich in gold; but, strange to state, where such was the

[1] From the Transactions of the Institution of Mining and Metallurgy, October 20, 1897.

case, little or no gold upon the surface was discovered, clearly proving that no denudation has taken place since the gold-bearing portions of the lodes were uncovered. One of the characteristic features of the Western Australian goldfields is the almost total absence of alluvial deposits containing gold. Those surface patches which have been worked owed their origin entirely to atmospheric agencies, which have also often altered the rocks and lodes to a considerable depth from the surface. Another peculiarity of the Hannan's field is the scarcity of quartz and absence of well-defined quartz veins, thus proving conclusively that the surface gold, which shows no sign of water action, is derived from the weathering *in sitû* of belts of country rock traversed by small but rich veins.

The lodes, when opened up in the decomposed zone, do not exhibit the general characteristics of true fissure veins, since they rarely have defined walls or slicken-sides to prove that any sliding action has taken place, and when they have, such walls are of limited extent. Moreover, it does not follow that all the material which appears to be lode matter between such walls, or between the points at which the solid blue country is met with, is all ore.

The whole lode formation has a banded or schistose appearance and is mostly of a brownish colour, due to the presence of hydrated oxides of iron; and it is soft and greasy to the touch, owing to the fact that it consists largely of hydrated silicates of alumina and magnesia.

Small decomposed quartz veins, which are often ferruginous, intersect the lode mass, and it is where these are met with that the lode is found to be richest, all the coarsest gold being associated with the quartz. When these veins are entirely absent, little or no gold is met with; and when it does occur, it is in a very finely divided state disseminated throughout the entire mass.

At the surface, the lodes apparently run in a more or less north and south course; and since there is not a continuous outcrop, an individual lode cannot be traced with the slightest degree of certainty for any great distance. This is further rendered difficult by the fact that several of these lodes are often met with close together, and following apparently the same course, or nearly so, as the lode which it is desired to follow.

There appear to be few continuous lodes, most of them proving to be lenticular. These lenticular masses are found to lie one on another in splice fashion; therefore, when one pinches, if a cross-cut is driven east and west, one or more lodes are almost certain to be cut at no great distance from that which has pinched; but although such lode or lodes may, to all appearances, contain similar material, it does not follow that it will be as rich in gold. The rich ore appears to run in well-defined shoots, which dip to the south, varying in width from a few inches to several feet, and in length up to several hundred feet; the entire mass of which mostly goes from 3 to 4 ounces, whilst large portions are often as rich as from 10 to 20 ounces.

This decomposed zone in the lode varies in places from 50 feet

to 300 feet from the surface; the greatest depths to which it has extended in many cases correspond with the richest portions of the lodes.

In the mineralized portions of the lode, a great change in its character is to be noticed, and it has, if anything, still less the appearance of a true lode than that nearer the surface; however, it continues to be equally as rich, but the gold, instead of being free, occurs in the form of a telluride. The ore is a bluish-green siliceous rock, often thickly studded with minute crystals of pyrites, and intersected by quartz veins, which are the richest portions of the lode; but here, as in the decomposed zone, the gold is found to extend often for a considerable distance into the mineralized rock upon either side of these veins.

Portions of this rock, taken from near the quartz veins, often contain large quantities of small crystals of telluride of gold, pyrites, calcite (which also occurs in veins and vughs), and probably serpentine, thus presenting an entirely different composition from the hornblende and felspar rocks which constitute the country rock, but into which it merges so gradually that it is impossible to say where one ends and the other begins.

The tellurides are met with as veins, splashes, and minute crystals disseminated throughout the entire mass. In the first of these forms, they appear to have been deposited subsequently to the quartz, for the veins intersect the latter, often filling right-angle cracks in them, which, when encountered, make a great show, since they may be seen in places all the way down the side of a shaft for 40 or 50 feet as veins several inches in width, but which upon being broken into only prove to be of slight thickness, with quartz behind them. Fortunately this is not invariably the case, for in many instances small solid veins of the tellurides, quite independent of the quartz, have been traced for a distance of 60 or 70 feet.

Origin of Lodes.—With regard to the origin of the lodes, the only explanation that is tenable is that advanced by Dr. Penrose in his Report upon the origin of the Cripple Creek lodes. This is, that a series of fissures has been formed without any yawning, gaping, or faulting, up which highly heated mineral solutions were forced which permeated the country rock on either side of these cracks, dissolving out certain of its constituents, and replacing them by others, thus altering the nature of the rock to a large extent near the fissure, and gradually less further and further from it until no alteration at all has taken place, and the country rock has remained in its original form.

When a number of these veins are met with, following the same general course, and at no great distance from each other, mineralization has taken place over a greater extent, thus presenting the appearance of a large lode, whilst when only one occurs, the zone of alteration is of course limited, and therefore the lode is said to be small or to pinch. It is almost needless to mention that the richest portions are almost invariably met with at the most highly mineralized points, and hence where the lodes are largest.

The depth to which the zones of decomposition occur vary very greatly, even in a short distance, and bear no relation to the surface contour or to the water-level of the country. At the same time, when the matter is carefully examined, the reason is apparently clear.

The rocks of the district, except in the immediate vicinity of the lodes, have undergone very little change, since they often outcrop, forming bold rough hills, which are strewn with solid masses of rock. When such is the case, and a lode-cap is cut, upon sinking to, say, 50 feet from the surface in the solid ground, it is found to have undergone little or no alteration, which is clearly due to the protection it has received by the 50 feet of solid rock above it that may be said to have hermetically sealed it.

On the other hand, when large rich lodes outcrop, the oxidizing action has followed gradually down the same channels, up which the mineral matter found its way, and has altered it to a considerable depth; whilst in those portions which were poor, and not so highly mineralized, little or no change has taken place, even in the same lode and at the same levels.

The gold in the oxidized zone is clearly derived from the decomposition of the tellurides, since the gradual change from one into the other has been traced, whilst, further, the pyrites proves to contain little or no gold.

II.—Differentiation in Igneous Magmas as a Result of Progressive Crystallization.[1] By J. J. H. Teall, M.A., F.R.S.

CRYSTAL building in an originally homogeneous igneous magma necessarily produces differentiation into portions of different chemical composition, a fact the importance of which was first impressed upon the author sixteen years ago in studying the andesitic lavas and their associated quartz-porphyry dykes in the Cheviot district.

As is well known, Professor Rosenbusch has classified the common constituents of igneous rocks into (1) the ores and accessory constituents (including magnetite, etc.), (2) the ferro-magnesian constituents, (3) the felspathic constituents, (4) free silica; and has maintained that members of group (1) are the first to form in the process of crystallization, and that while there are irregularities of order between members of group (2) as compared with those of group (3), yet the members of these groups separate out *inter se* in the order of increasing acidity. This order of crystallization has been emphasized by many writers, though it has also been clearly recognized that the law is not constant in different magmas and under different conditions. The object of the present communication is to call attention to what is at least an important exception to this law.

Among an extensive series of rocks and fossils collected by the

[1] Abstract of a paper read at the British Association, Section C (Geology), Toronto Meeting, 1897.

Jackson-Harmsworth expedition in Franz Josef Land, recently examined by the author and Mr. E. T. Newton, are many basalts essentially composed of labradorite, augite, and interstitial matter, in which labradorite formed first, then augite, and last of all the interstitial matter, either with or without further differentiation. The main interest of these rocks lies in the composition and relations of the interstitial matter. This is occasionally present as a deep brown glass, but more often is represented either by palagonite or by a turbid and more or less doubly refracting substance crowded with skeleton-crystals of magnetite. In many specimens it is only in this form that the magnetite occurs, the labradorite and augite being free from inclusions of this mineral. These facts prove that magnetite may belong to a very late stage of consolidation, and that progressive crystallization may lead to a concentration of iron-oxides in the mother liquor.

The palagonite appears to have been formed by the hydration of a deep-brown glass. An analysis was made of it with the following results :—

	I.	II.
Silica	35·48	42·88
Titanic acid	nil	—
Alumina	8·30	10·03
Ferric oxide	12·30	14·87
Ferrous oxide	14·60	17·65
Lime	1·04	1·26
Magnesia	7·10	8·58
Soda	3·92	4·73
Potash	trace	—
Loss on ignition	16·80	—
	99·54	100·00

In the second column the water is neglected, and the percentage composition of the remaining substances indicated. The analysis confirms the view that a great concentration of iron-oxide has taken place, and suggests the further conclusion that there has been a concentration of magnesia and a reduction of the lime, silica, and alumina, thus agreeing with the results of the microscopic examination.

Several observers are quoted by the author as having established the fact that magnetite is not always one of the earliest minerals to form, and in basalts of the Franz Josef Land type there is clear evidence that a basic magma may consolidate without any separation of this mineral, although the mother liquor may contain 30 per cent. of iron-oxides.

Brögger, Vogt, and others have observed a tendency in certain dykes for the molecular groups of which the first-formed minerals are built to migrate towards the cooling margins. The cases examined are mostly those of intermediate rocks, in which the basic minerals are the first to form, so that the margins are more basic than the central parts. But it appears probable that cases occur in which the opposite is true. If the magma of the Franz

Josef Land basalts had cooled slowly in a fissure, we should expect to find the central portion of the dyke richer in iron-oxide than the margin. Professor Lawson has described two basic dykes from the Rainy Lake region, where this is actually the case, and a more striking illustration is seen in the Taberg iron-ore mass, described by Sjögren and Törnebohm, where the marginal portion of an eruptive mass about one square kilometre in area is formed of olivine-hyperite containing only small quantities of magnetite and olivine, and this passes inward by gradual stages into a magnetite-olivinite without plagioclase.

In conclusion, it is asked whether the metallic iron, which occurs as interstitial matter in some of the Greenland basalts, may not have been formed by the reduction, by included organic matter, of the iron-oxides previously concentrated by progressive crystallization.

III.—Drift Phenomena of Puget Sound and their Interpretation.[1]

By Bayley Willis.

THE area from which the facts for this discussion were collected is the Tacoma quadrangle of the United States topographical survey, comprising the district east and south of Seattle and Tacoma. The major topographic features are the channels of the Sound and the strictly homologous valleys now filled with alluvium. These divide, and in some instances surround, plateau-like elevations composed of stratified and unstratified drift that rise about 500 feet above the sea. On the slopes of the adjacent foot hills of the Cascade Range, drift deposits occur up to and beyond 1,700 feet above the sea. Various features of the Glacial-derived topography have been traced out in detail, including characteristic till surfaces, morainic zones, kames, and overwash plains. The distribution of these features indicates that at least the latest Glacial advance was along the valleys and channels of the Sound, and that glaciers rose above and overflowed the margins of the plateaus. The materials of the drift are to a large extent granite, and bear evidence of prolonged water transportation. A distinct variety of till, containing numerous erratics of Tertiary volcanic origin, was found in localities to which it was probably brought from the local centre of glaciation, Mount Rainier. The relation of these local Glacial deposits to the general drift indicates that the prevailing drift phenomena were due to glaciers which penetrated from the north as far south as the foot hills of Mount Rainier, thirty miles south-east of Tacoma.

The detailed examination of the various features of the drift suggests the hypothesis that the channels of the Sound are the hollows remaining after repeated Glacial occupation of a wide valley formerly diversified by the valleys and ridges of Pre-Glacial topography. In the course of repeated Glacial advance and retreat the earlier divides were built upon and transformed into plateau-like

[1] Abstract of paper read before the British Association, Section C (Geology), Toronto, 1897.

eminences of Glacial drift, whereas the occupation of the valleys by Glacial ice, particularly in the stagnant stages of retreat, prevented their being permanently filled; with the final retreat of the ice the molds of glaciers remained as the channels of the Sound. This hypothesis is to be contrasted with that of erosion, due to repeated uplift and subsidence.

IV.—Life-Zones in the British Carboniferous Rocks.—Report of the Committee, consisting of Mr. J. E. Marr (Chairman), Mr. E. J. Garwood (Secretary), Mr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Dr. Wheelton Hind, Dr. G. J. Hinde, Mr. P. F. Kendall, Mr. R. Kidston, Mr. J. W. Kirkby, Mr. G. W. Lamplugh, Professor G. A. Lebour, Mr. G. H. Morton, Professor H. A. Nicholson, Mr. B. N. Peach, Mr. A. Strahan, Dr. Traquair, and Dr. H. Woodward, appointed to study the Life-Zones in the British Carboniferous Rocks. (Drawn up by Mr. Garwood.)[1]

In consequence of the early date on which it is necessary to submit reports, little work has been done this year up to the present time, but it is hoped that during the summer months progress may be made with the work of the Committee, and collections may be obtained from localities of special importance.

At present a collector is engaged upon the fauna of the Millstone Grit at Eccup, five miles north of Leeds, where a fossiliferous black shale has been met with during the excavation of a puddle-trench for a reservoir. The bed occurs about the centre of the "Middle Grits" of the Yorkshire Millstone Grits.

The bed, which was discovered by Mr. Percy Kendall, some three years ago, contains a rich marine fauna, which has not yet, however, been properly worked out. The fauna includes species of *Nucula* and *Leda* in great abundance and in excellent preservation, also numerous individual specimens of *Lingula* and *Discina*. Gasteropods occur, and a few specimens of *Goniatites*, together with well-preserved specimens of *Conularia*. Several specimens of *Dithyrocaris* have been found, and a single specimen of a minute Trilobite, cf. *Brachymetopus Ouralicus*. Fish-remains referable to two genera have been identified.

The fauna appears to bear little resemblance to that of the Cayton Gill beds of Nidderdale, which lie at approximately the same horizon in the Millstone Grit. On the whole, the fauna appears to resemble in many points that of the Ridsdale Ironstone shale of the Bernician beds of South Northumberland. The Committee hope that the information obtained from this deposit will be of value, in consideration of the comparative neglect with which the fauna of the Millstone Grit has hitherto been treated.

Owing to the temporary nature of the exposure, the Committee considered it advisable to expend a considerable portion of the grant in obtaining the services of a competent collector, who has spent

[1] Read before the British Association, Section C (Geology), Toronto, 1897.

a fortnight in making as exhaustive a collection as possible from the locality, under the superintendence of Mr. Percy Kendall. The accounts have not yet, however, come in, and the Committee cannot therefore at present draw upon the grant generously placed at their disposal by the Association, but ask that the sum granted may be carried over to next year. They also ask that a similar sum may be granted for that year.

The Secretary has been in correspondence with the various members of the Committee as to the best methods of forwarding the objects of the Committee. From many of these he has received valuable suggestions; and it is hoped that reports will be furnished at an early date from each of the members for special districts, giving detailed sections of the rocks in their individual areas, and stating what reliable information has already been collected regarding their fossil contents, and what yet remains to be done in this connection.

REVIEWS.

I.—A Memoir of William Pengelly, of Torquay, F.R.S., Geologist; with a Selection from his Correspondence. Edited by his Daughter, Hester Pengelly, with a Summary of his Scientific Work, by the Rev. Professor Bonney, F.R.S., F.G.S., Honorary Canon of Manchester. 8vo; pp. xii and 342, with a Portrait and 10 plates. (London: John Murray, Albemarle Street, 1897. Price 18s.)

IF it be true that "there's a divinity that shapes our ends, rough-hew them how we will," it is also a trite observation that the physiography and geology of a man's birthplace and early home often exercise a most powerful influence upon his character and career in after life.

Take the case of Hugh Miller, born at Cromarty, with the sound of the sea for ever in his ears. His father, an owner of some small vessels employed in the coasting-trade, was drowned when the boy was only five years old. Subsequently Hugh was apprenticed to a mason. Who can doubt that the environments of the boy helped to form the thoughtful, self-reliant man and the geologist?

In like manner William Pengelly, the subject of the present volume, being born at the fishing village of East Looe, in Cornwall, went to sea with his father and followed for years the life of a sailor-boy. Here, too, as in Hugh Miller's case, the surroundings of his early days doubtless helped to impart that geological bias to his thoughts, that vigour and energy to his mind and body, for which he was subsequently distinguished.

For an agreeable and instructive "Life" of this eminent man of science, the well-known Torquay geologist, we are indebted to his younger daughter, Miss Hester Pengelly. The adventures of his hardy boyhood are of necessity autobiographical. For later years his wife's letters to her mother and her invalid sister in part supply

the want of a diary. His own familiar letters to his wife and children will be read with pleasure by many who care little or nothing for cave-earth or bone-beds, or the sabre-toothed tiger. Of his numerous contributions to scientific literature Professor Bonney has given a clear and appreciative notice, which forms a valuable addition to this excellent volume. The unremitting and gratuitous labour which Pengelly for many years devoted to the exploration of Kent's Cavern met with a reward of a rather unusual kind. As a poor fisher-lad he was perforce content to exchange ideas with retired smugglers and other good honest folk of that description. In mature life he was positively courted by all ranks of society, from queens and emperors down to ordinary tourists and literary men. His extremely clear, and at the same time humorous, style of lecturing won him the public ear, and the controversial interest attaching to the Cavern exploration made him for many years the man of most mark among the residents at Torquay. Of his methods of exposition one charming instance may be quoted (see pp. 231–3). Accompanied by a rustic as guide to a particular locality in Cornwall, Pengelly was searching for the Devonian fossil *Steganodictyum*, now known to be a fish. Having found a specimen, he immediately set to work with hammer and chisel, on his knees, endeavouring to extract it; whilst John exclaimed:

"'Why, what be about?'

"'Do you see this black patch?'

"'Ees, I zee it plain enough.'

"'Well, that's a fossil, and I'm trying to get it out.'

"'Oh, that's a fossil, is it? What is a fossil?'

"'Sit down, John, and I'll try to explain. Do you suppose there are any dead shells, or fish-bones, lying on the bottom of the sea yonder?'

"'Of course there is.'

"'What is the state of the river, in yonder beautiful valley, after heavy rain?'

"'Why, very muddy.'

"'When there is a very heavy gale, throwing violent waves on this cliff, does the cliff ever give way?'

"'Oh yes, there's always some part or other wasting.'

"'Very well. Now, the mud which the river brings down from the country, as well as that which the waves tear from the cliffs, finds its way to the sea, as you know, and sooner or later it settles on the bottom of the sea, and buries up such remains of dead animals or vegetables as may be lying there, and forms a new sea-bottom; on which, by-and-by, other shells, and things of that nature, will find their way; and these will be buried in their turn. Now, if this work goes on for a very long time, the mud and sand carried into the sea will form a very thick mass; and if you can suppose it to become more or less hard, it will be a rock, with remains of animals in it. And if it should from any cause get raised above the sea, the waves would begin to break it up, little by little, just as you break up the rock on which you are sitting; and after a while any person

who carefully looked for them would be able to see the shells and fish-bones, and so on, that had been buried very long before, and he would call them fossils.'

"'But do you mean to say that that 's the way that black thing got into the rock?'

"'Yes, that 's what I mean to say.'

"'Was this rock mud once?'

"'Yes.'

"'Not made when the world was made?'

"'Oh, dear no! It was made very long since. There are rocks of very great thickness in other parts of the world, made in the same way, and some of them are much older, and others much newer, than this.'

"'Well, you *have* opened my eyes. I 'll tell 'ee what 't is—I 've lived longer this morning than in all the years of my life before. So that 's a fossil, is it? Was it a shell or a fish-bone?'

"'There 's a difference of opinion about it at present. None of them are very perfect; and some say it 's a piece of sponge, whilst others think it 's part of a fish.'

"'Well, never mind! 't is a fossil: let me look at 'en, and then I 'll try to find some.'

"He accordingly proceeded to inspect the rocks, and in a few minutes cried out—

"'Here 's one. Here 's another,' and, in a short time, detected several good specimens.

"On our journey back, John asked me numerous questions, most of them very pertinent, and some of them by no means easy to answer. At the inn I betook myself to the 'parlour,' in order to greater quietude for writing. John felt himself happier in the kitchen; but, as the one room opened out of the other, I frequently heard my zealous disciple repeat to the villagers who came in from time to time—though with sundry modifications and some errors—the lecture he had heard in the morning, the invariable peroration being: 'I 'll tell 'ee what 't is—I 've lived longer this morning than ever I lived all the years of my life before.'"

It was not only as eyes to the blind, or in the instruction of simple and ignorant people, that Pengelly distinguished himself. His correspondence shows that he met on equal terms the leading men in his own branch of science, and especially that he was an adviser in whom Sir Charles Lyell placed a large and generous confidence. If in one of his letters to Lyell, Pengelly is made to speak of *Cheirudidæ* and *Cyphuspidæ* and of *Phacops cryptoptophatinus*, one can only hope for a speedy second edition of the book, in which these casual misprints may be corrected.

That Pengelly had many lovable traits of character, not a few of his friends would willingly testify. That he was never in opposition, never in the wrong, never out of temper, never tempted by his great abilities to exercise an imperious sway, need not be inferred from the fact that these "humanities" are not mentioned in a biography compiled with filial delicacy and tact. He was a very shrewd and

sometimes an unsparing judge of the characters of other men. He was a born logician. Of his geniality it is enough to say that social gatherings at which he consented to be a guest were sure to be successful. The simplicity of his tastes, of his mode of living, and of his general demeanour, was never spoiled by the flattery, direct and indirect, of which he was so frequently the recipient. To his scientific purposes he stuck unflinchingly, and he was no less staunch to his friends.

II.—Maryland Geological Survey. Vol. I, 1897. 8vo, pp. 539. (Baltimore: the Johns Hopkins Press.)

THE present State Geological and Economic Survey of Maryland was established in 1896. Its objects are—(1) an examination of the geological formations of the State, with especial reference to their economic products, such as building-stones, clays, ores, and other mineral substances; (2) an examination and classification of the soils and a study of their adaptability to particular crops; and (3) an examination of the physical features of the State with reference to their practical bearing upon the occupations of the people. It was decided that these objects should be duly carried out by the preparation of maps and reports; and Dr. William Bullock Clark, Professor of Geology in the Johns Hopkins University, was happily chosen as State Geologist.

The present handsome volume is intended to serve as a preliminary account of the physiography, geology, and mineral resources of Maryland. It is well printed, and well illustrated, with excellent coloured maps and pictorial views; and we may heartily congratulate the State and the State Geologist on this first instalment of the great work which has been undertaken.

There is no doubt that in any Geological Survey organized at the public expense, the main endeavour must be to determine and to assist in developing the economic resources of the country. Such work can only be carried out by those who possess scientific training and enthusiasm; and while in all geological surveys there must naturally be a blending of pure science with applied science, it must always be remembered that the applied science is of most interest and of most importance to the community.

Professor Clark gives an instructive Historical Sketch of the progress of investigation into the physical features and natural resources of Maryland, and this is supplemented by a copious Bibliography and Cartography of the State, drawn up by Mr. E. B. Mathews. It is interesting to learn that the earliest reference dates back to 1612, while the earliest notice of certain clays and gravels was published by Captain John Smith in 1624. The mother-country can hardly go back further than this. Brickyards and iron-mines were opened during the seventeenth century; and many miscellaneous notes on minerals and other subjects were from that time published.

The first State Geological Survey was made during the years 1834–41, almost as soon as Great Britain had been induced to recognize the desirability of having an official geological survey.

Later on, from 1848 to 1862, investigations were carried on by the State Agricultural Chemists; and Mr. Tyson prepared a geological map of the State on the scale of 12 miles to an inch. As Professor Clark observes, this was "by far the most complete representation of Maryland's geology that had been attempted up to that time." In 1887 the Experiment Station of Maryland was called into existence for research-work in agricultural and kindred subjects.

Meanwhile the organization of the Johns Hopkins University in 1876 had inaugurated a new period of scientific activity in Maryland. "The laboratories of the University were equipped for the study of the broadest problems of scientific enquiry. . . . . The Geological Department was organized in 1883, when Dr. George H. Williams began his connection with the institution as an instructor of mineralogy. His appointment marks the beginning of a period of investigation of the geology and mineral resources of the State that has been carried on by his associates and successors continuously to the present day." This period, as Professor Clark shows, has been by far the most important in the study of the geology of Maryland. Almost from the first the members of the geological department have carried on their investigations in close co-operation with the United States Geological Survey, and frequently as members of its staff; and this official co-operation will be maintained. In 1887 Professor Clark joined the University as instructor of stratigraphic geology and palæontology, and his researches on the Cretaceous and Eocene formations in particular are well known.

The new Survey will be based on topographic maps executed by the United States Geological Survey, and these will be published on the scale of two miles to an inch. As the State extends from the Atlantic Ocean to the crest of the Alleghanies, it comprises a great variety of physical features, of geological formations, soils, and mineral resources. Professor Clark gives a comprehensive outline of the present state of knowledge on these matters; and in his Table of Maryland Formations he notes Archæan, Cambrian, Silurian, Devonian, Carboniferous, Permian (?), Triassic, Jurassic (?), Cretaceous, Eocene, Neocene, and Pleistocene. The local formations are indicated by distinctive terms such as the Juniata (red Medina), and the Tuscarora (white Medina) in the Silurian, the Mauch Chunk in the Carboniferous, and the Pamunkey in the Eocene. After giving an account of the numerous formations Professor Clark devotes attention to the Mineral Resources, including Building and Decorative Stones, Slate, Limes and Cements, Clays, Sands, Porcelain Materials, Marls, Iron Ores, Coals, Gold, Mineral Paints, Diatomaceous Earth, Mineral Waters, Road Materials, and miscellaneous products. The volume concludes with a First Report upon Magnetic Work, contributed by Mr. L. A. Bauer.

We heartily compliment Professor Clark on this successful commencement of his work, and more especially so as nothing which this country has been able to issue in connection with its Official Geological Survey can compare, in its mode of presentation to the public, with this First Report of the new Geological Survey of

Maryland. It is strange that the British Survey has always laboured under difficulties, and that its staff and equipment have been inadequate to deal with many matters of economic interest which other countries find it wise to thoroughly investigate.

III.—(1) Beiträge zur Kenntniss der obertriadischen Cephalopoden-Faunen des Himalaya. By Dr. Edmund Mojsisovics Edler von Mojsvar. Denkschr. d. k. Akad. d. Wissenschaften, Wien, math.-naturw. Classe, Bd. lxiii, pp. 575–701, pls. i–xxii, 1896.

(2) Himalayan Fossils. The Cephalopoda of the Muschelkalk. By Carl Diener. Mem. Geol. Surv. India. Palæontologia Indica, ser. xv, vol. ii, part 2, 118 pp., xxxi pls., 1895.

WHEN the older collections from the Himalayan Trias were described, species were regarded in a much wider sense than obtains nowadays; hence, before the correlation of the Indian Trias with the Triassic rocks of other countries could be attempted, it was necessary for these collections to be re-examined and fully described.

Accordingly, at the suggestion of Mr. Griesbach (now Director), the Geological Survey of India consented to send all their collections of Himalayan fossils to Professor Suess in Vienna, in order that they might be worked out by Austrian specialists. (1) The Cephalopoda were entrusted to Dr. E. Mojsisovics, who has done so much work on the Cephalopoda of the Austrian Trias; and he at once saw that by far the larger number of the specimens came from the lower portion of the Trias, and that the upper beds were represented by only a few specimens. Recognizing the scientific interest which a more detailed knowledge of the Himalayan Trias would have, in some "Preliminary Remarks on the Cephalopoda of the Himalayan Trias," which Dr. Mojsisovics communicated to the Imperial Academy of Sciences, Vienna, he advocated the sending out of a special expedition to the Himalayas to collect Triassic fossils, and indicated the more important and more promising localities at which collections should be made. Thanks to the liberal response of the Director of the Indian Geological Survey, who obtained the necessary funds from the Indian Government, and owing also to the liberality of the Imperial Academy of Sciences in Vienna, an expedition was sent out, consisting of Messrs. Griesbach and Middlemiss, of the Indian Geological Survey, and Dr. Diener, of Vienna. The expedition was made during about five months of the year 1892, and proved very successful, extensive collections being made. These were also sent to Vienna, and the Triassic Cephalopoda contained therein form by far the greater part of the material which is described in the present memoirs. The Upper Triassic forms have been dealt with by Dr. E. von Mojsisovics, whilst Dr. Diener himself has described the fauna of the Muschelkalk, and will describe also that of the Lower Triassic rocks.

The first discovery of Triassic fossils in the Himalayas is due to Captain (now Sir Richard) Strachey, who communicated an account of his geological discoveries in the Himalayas to the Geological

Society of London in 1851. Professor Suess, who saw these specimens during a visit to London, recognized the Alpine character of some of the fossils, and even went so far as to identify some of them with species which had already been described from the Alps. In 1863, in his description of Dr. Gerard's collection of fossils from the Spiti valley, H. F. Blanford described two Triassic Ammonites, and observed that the Triassic specimens were not sufficiently numerous to lead him to infer the existence of a distinct formation of that age; he stated, however, that the investigations of Mr. Theobald, who had just returned from a visit to the Spiti valley, established the existence there of Triassic rocks, as well as rocks of Silurian and of Upper Oolitic age. In this same year Oppel began his important memoir on the fossils collected by the brothers Von Schlagintweit in Tibet and Spiti during the years 1854–7; and, although the collectors did not state the geological horizon at which the fossils had been obtained, Oppel inferred, from an examination of the specimens, that they had not all been found in the Spiti Shales, and some two years later he assigned a number of them to the Trias. In 1864 Professor Beyrich described a couple of fragments of Triassic Ammonites which had been brought from Ladakh. Salter, in his description of Strachey's Triassic fossils which appeared in the following year, regarded them as of Upper Triassic age; Dr. Diener, however, states that most of the Cephalopods that he described belong to the Muschelkalk, and that the few real Upper Triassic forms that he identified with European species were not correctly determined. In the same year, from an examination of the brachiopods and bivalves of the Schlagintweit collection, Gümbel came to the conclusion, not only that rocks of Triassic age were present in Spiti, but that two horizons could be recognized, an upper and a lower; the former he regarded as the equivalent of the European Muschelkalk, and the latter as comparable with the Werfen beds of the Alpine Trias.

In his memoir on the Cephalopoda of the Alpine Muschelkalk, Professor Beyrich pointed out that most of the Triassic Ammonites described by Oppel were more nearly related to species from the Muschelkalk than to Upper Triassic forms, and he considered that a great portion, at least, of the Triassic deposits of the Himalayas should be regarded as homotaxial with the Alpine Muschelkalk. Stoliczka, however, who visited Spiti in 1864, believed that only Upper Triassic rocks were present, and that representatives of the rest of the Triassic rocks were entirely wanting in this part of the Himalayas; nor did he consider that their presence had been proved in any other portion of these mountains, an opinion which he still maintained after a subsequent visit to these regions. Griesbach, on the contrary, after a visit to Niti, stated that there "the whole Trias, from the Alpine Werfen beds (Buntsandstein) to the Upper Keuper rocks," was present. After an examination of all the Triassic Cephalopoda in the Museum of the Indian Geological Survey at Calcutta, including Stoliczka's type-specimens, Dr. Diener considers that probably only two species are undoubtedly of Upper Triassic age, two others being somewhat doubtful, whilst all the rest are

characteristic forms of the Indian Muschelkalk. That the Himalayas do contain, not only Upper Triassic rocks, but beds both of Muschelkalk and of Lower Triassic age, there is now no doubt; in fact, they contain the richest development of the Lower Trias that has hitherto been discovered.

In the Cephalopod fauna of the Upper Triassic rocks here described the Nautiloids are represented by the genera *Pleuronautilus*, *Nautilus*, *Clydonautilus*, and *Orthoceras*, and the Dibranchiates by some phragmocones of *Atractites*; but by far the larger portion of the fauna consists of Ammonoids. In addition to Himalayan forms Dr. Mojsisovics also describes and figures a new *Didymites* (*D. afghanicus*) from Afghanistan, and an indeterminable species of *Stenarcestes* from New Caledonia. Several new genera and subgenera are proposed; and altogether seventy species are described as new and are named, whilst many forms which are regarded as new the author considers to be too imperfectly known to be named. So minutely is the fauna described that it amounts almost to the description of individual specimens, for of the seventy new species that are described thirty-three are based upon single specimens. All the species are exceedingly well-figured on the twenty-two plates accompanying the memoir. Dr. Mojsisovics arranges in a tabular form the different zones that he has been able to identify in the Indian Trias Province, and indicates their relation to the zones that have been established in the Mediterranean Trias Province. He considers that the fauna of the Indian Province, although distinct from that of the Mediterranean Province, shows that there was during the Upper Trias period a sea connection between the two regions; the Mediterranean Province was, in fact, the westerly extension of the great Triassic sea—named by Professor Suess the Thetys—which occupied the present mountainous regions of Asia, extending in an easterly direction as far as the present Pacific Ocean. The author concludes his memoir with some interesting remarks on the sea of the Triassic Period.

(2) Dr. Diener divides his memoir into two portions, the first part dealing with the Muschelkalk fauna of the main region of the Central Himalayas, the second being devoted to that of the Triassic limestones of Chitichun, to the north of the main region. In the fauna of the main region the Nautiloids are represented by the genera *Nautilus* and *Orthoceras*; the Dibranchiates by the genus *Atractites*; and the Ammonoids by the genera *Ceratites*, *Danubites*, *Japonites*, *Acrochordiceras*, *Sibirites*, *Isculites*?, *Proarcestes*, *Lobites*?, *Meekoceras*, *Gymnites* (with the new subgenus *Buddhaites*), *Sturia*, and *Ptychites*. Thirty-two new species are described; nineteen are founded upon single specimens, fifteen of which are stated to be in the author's collection, whilst of the thirteen species founded on more than one example, in six cases all the examples of the species are also in the same collection. Dr. Diener agrees with Dr. Mojsisovics in regarding the Muschelkalk fauna of the central region of the Himalaya as a connecting-link between that of the Arctic-Pacific on the one side, and that of the Mediterranean on the other, but points out

that it contains a considerable number of forms which are peculiar to it, and impart to it the character of a zoo-geographical region of its own.

The Muschelkalk of the main region of the Central Himalayas is divisible into two portions: the lower ranges from three to six feet in thickness, and is characterized chiefly by a Brachiopod fauna; the upper has a thickness of from 15 to 40 m. or from about 50 to 130 feet, and has yielded a very rich Cephalopod fauna. Dr. Diener says that "so far as such palæontological analogies may be permissible in correlating formations geographically so widely separated, we may consider the main mass of the Himalayan Muschelkalk to be an equivalent of only the Upper Alpine Muschelkalk of the Mediterranean Triassic province."

Nowhere in the Himalayan Trias have deposits of Norian and Lower Carnian Age been met with between the Muschelkalk and the *Daonella*-beds, the uppermost bed of the Muschelkalk being conformably overlain by a limestone yielding an *Aonoides*-fauna. Hence it would seem that possibly the Indian Muschelkalk is the homotaxial equivalent of the Muschelkalk and of the Norian stage of the Mediterranean Province, but Dr. Diener considers that our present knowledge of the palæontological evidence does not justify us in this conclusion.

The Triassic limestone of Chitichun occurs only in detached blocks, and is lithologically entirely different from the Triassic beds of the main region. Dr. Diener regards its fauna as of Muschelkalk age, but belonging to a somewhat lower horizon than that of the main region of the Central Himalayas.

Both memoirs are illustrated by numerous excellent plates, and form a most important contribution to our knowledge of the Indian Triassic Cephalopoda. We look forward with interest to Dr. Diener's work on the rest of the Triassic Cephalopoda of these regions.

IV.—The Geology of the Country around Liverpool, including the North of Flintshire. With Appendix and Geological Map of the District. By G. H. Morton, F.G.S., etc. New Edition. 8vo; pp. 319, with 22 Plates and 15 Woodcuts. (G. Philip & Son: London and Liverpool, 1897.)

AS a veteran resident geologist, the author has long been accustomed to note and collect everything remarked by himself and others about his favourite subject of research, namely, the geological history of the district within a radius of about twenty miles around Liverpool, but for the most part limited to places within about twelve miles. The first edition of this work, issued in 1863, was reviewed in *The Geologist*, vol. vi, p. 478; the second edition was reviewed in the Geological Magazine, Dec. III, Vol. VIII, p. 226. The present edition begins with a reprint of the "Preface to the Second Edition," dated 1891; and the "Preface to the Appendix," at p. 291, accounts for the additional six years, in which much local information has accrued for the production of this "New Edition" (1897).

A list of the principal works and papers on the geology of the

neighbourhood of Liverpool, from September, 1890, to the end of 1896, comprises thirty-three papers, chiefly published in the Proceedings of the Liverpool Geological Society, the source also of a large proportion of the material referred to in the former editions, for which a bibliography would have been highly useful. The memoir last quoted in the list is Mr. Morton's condensed account of the geology of the district under notice, prepared as a handbook for the British Association Meeting in 1896, and accompanied with a geological map based on the Geological Survey Map, Sheet 79, N.E., and portions of the adjoining sheets, so as to include the Coal-measures lying to the north-east of Liverpool. Some details of the National Map, such as the actual coal-seams and faults, which are often the boundaries of the exposed formations, are omitted; and some important patches of the Red or Keuper Marl have been introduced.

If the colours on the map and its index had been numbered with successive figures, there would have been less difficulty in recognizing the several faint tints of red and pink.

The corrected list of the Formations and their estimated thicknesses in South-West Lancashire, including Wirral (the large peninsula south-west of Liverpool, between the Mersey and the Dee), and of North Flintshire, is as follows :—

South-West Lancashire and Wirral.			Feet
Recent		Blown Sand and Estuarine Sand and Silt	100
Pleistocene	Post-Glacial	Peat and Forest Beds, Silt and Sand	25
	Aqueo-Glacial	Boulder-clay and Sand	100
	Pre-Glacial	Cave-deposits (in Flintshire and Denbighshire)	2
Trias	Keuper	Red Marl	1000
		Keuper Sandstone	400
	Bunter	Upper Soft Sandstone	550
		Upper Hard Sandstone	400
		Lower Hard Sandstone (with pebbles)	600
		Lower Soft Sandstone	400
Permian		Magnesian Limestone	10
		Marl and Soft Sandstone	100
Carboniferous	Coal-measures	Upper Coal-measures	1200
		Middle or Productive Coal-measures	1300
		Lower Coal-measures	1880
	Millstone-grit	Millstone-grit	300
			8,367

North Flintshire.			Feet	
Carboniferous	Coal-measures	Middle or Productive Coal-measures	700	
		Lower Coal-measures	300	
	Cefn-y-Fedw Sandstone	Gwespyr Shale	150	1
		Gwespyr Sandstone	120	
		Holywell Shale	100	
		Cherty Sandstone (with shale)	250	
	Carboniferous Limestone	Upper Black Limestone	200	
		Upper Grey Limestone	500	
		Middle White Limestone	600	
		Lower Brown Limestone	400	
		Red Basement-beds	3	
			3,323	

[1] These are represented in South-West Lancashire by the Middle and Lower Coal-measures and Millstone-grit.

Not much has been added to our knowledge of the local Coal-measures, the Permian, and the Bunter Sandstone. Permian fossils, however, have lately been found by Mr. E. Dickson at Skillaw Clough, near Parbold, namely: *Gervillia antiqua*, *Mytilus squamosus*, *Pleurophorus costatus*, *Schizodus obscurus*, and *S. rotundatus* in the purple shales, and *S. Schlotheimi* in the limestone; thus adding to the late Mr. E. W. Binney's fossils from the same limestone, and confirming Dr. E. Hull's discovery of the Formation in that district.

The Red Keuper Marl has been proved to have a much greater thickness than was formerly supposed, being 1,000 instead of 400 feet; the whole thickness of the Liverpool Trias is now calculated at 3,350 feet (p. 297). In the equivalents in Cheshire of the Bunter Pebble-beds of the Midlands, the pebbles occur only scattered in the lower 600 feet, and are altogether absent in the upper 400 feet. Hence these cannot be well termed Pebble-beds; and Mr. Morton has replaced that name, as far as his district is concerned, by the "Upper" and the "Lower Hard Sandstone."

At Bidston, in Wirral, a boring has been made to the depth of at least 2,850 feet; but the characteristics of the several strata are not known, the particulars having been withheld by the promoters. Some brine was met with, but no coal, though it was expected to have been found at 2,000 feet, according to the calculated thickness of the Triassic beds in the locality. Probably a local depression of the Coal-measures was met with there.

At page 299, Mr. Morton explains that he has now reason to believe in there being six kinds of fossil footprints in the Keuper Sandstone at Storeton and elsewhere, which he here names, describes, and figures, namely:—

Chelone rotundata, Morton, pl. xii, fig. *d*.
Cheirotherium (known also as *Labyrinthodon* and *Cheirosaurus*) *Storetonense*, Morton, pls. viii–xi. The trail of the animal's tail [or body (?)] is figured on pl. xxii.
C. minus, Morton, pl. xxi, figs. *a* and *b*.
Rhynchosaurus articeps, Owen, pl. xii, fig. *a* (three largest).
R. minimus, Morton, pl. xii, fig. *c*.
R. tumidus, Morton, pl. xii, fig. *a* (two smallest).

Equisetites Keuperina, Morton, p. 115, pl. xii, fig. *f*, is another fossil named by Mr. Morton. It was determined by Mr. F. M. Webb in or before 1891.

Lists of characteristic fossils are given for the different formations successively described in detail, with the necessary sections, from the lowest upwards, throughout the volume. This book is invaluable to those who have, either persistently or incidentally, to study the physical features, the geological structure, the products, and the capabilities of the country. The changes which the surface, from the earliest times, whether along the coasts, or in the river-valleys, or on the more elevated grounds, has undergone from the action of the air, water, or ice, enlarge the field of inquiry for the physicist; and their study is a source of pleasure to the scientist, whether professional or amateur.

Mr. Morton has continued to add to the general stock of knowledge on all these points; and the Appendix (pp. 293–319) indicates, among other things, an extended acquaintance with ice-scratched surfaces at and near Liverpool. These local "glacial striæ" were more probably (p. 302) made by "bergs and pack-ice," "brought by the wind and tides from the north and north-west over the low-lying Triassic rocks of South-West Lancashire and Wirral," than by "the action of an enormous glacier, of which there is no probable evidence." Further notes and particulars about the erosion on the coasts, especially at the Leasowe on Wirral, are communicated; as well as the results of Mr. Morton's careful research as to the range of species in the Carboniferous Limestone of North Wales.

T. R. J.

V.—Appendix to the Geology of the Country around Liverpool, with a Geological Map of the District. By G. H. Morton, F.G.S. 8vo, pp. 293–319. (Liverpool: George Philip and Son, 1897. Price, 4*s.* 6*d.*)

THIRTY-FOUR years have passed since the first edition of Mr. Morton's well-known work on the Geology of Liverpool was published. A second edition was issued in 1891, and now the more recent researches have rendered desirable an Appendix. The map, which is printed in colours, shows very clearly the distribution of the various formations, exclusive of the mantle of Glacial Drifts. It is based on the work of the Geological Survey, but contains important additions and revisions. The term "Pebble-beds" of the Bunter is replaced by that of the Upper and Lower Hard Sandstone, because in Cheshire and South-West Lancashire scattered pebbles only occur in the lower beds, and they are absent altogether from the upper portion of the series. The total thickness of the Keuper Marl is now known to be 1,000 feet. Three plates illustrating remains of *Cheirotherium* are added. The author gives further notes on the range of species in the Carboniferous Limestone of North Wales; and he contributes particulars relating to the erosion of the sea-coast, glacial striæ, and recent deep borings.

VI.—Florentino Ameghino. La Argentina al través de las últimas épocas Geológicas. Disertación pronunciada en el acto de la inauguración de la Universidad de La Plata (18 de Abril de 1897). (Buenos Aires, 1897.)

THE present lecture, delivered on the day of the inauguration of the La Plata University, covers the same ground as a former paper by the author, of which a translation was published in this Magazine;[1] so that Mr. Smith Woodward's remarks accompanying the translation apply on the whole to the present paper as well. What is new are the text-figures, accompanied by very short characteristics of the oldest hitherto known Mammalian fauna of Argentina, from the *Pyrotherium*-beds. The figures are taken from the author's forthcoming memoir in vol. xviii of the *Boletin del*

[1] Geol. Mag., Dec. IV, Vol. IV, 1897, pp. 4–23.

Instituto Geografico Argentino, which will contain a full description of these "Cretaceous" Mammalia.

What is before us for the present certainly shows that the fauna of the *Pyrotherium*-beds possesses a somewhat more archaic facies than the one from the Santa Cruz beds. This is especially seen in the teeth, which throughout the groups are no more rootless, but have long roots with comparatively short crowns. But, apart from this, all the forms appear to be still so much specialized, that the author will probably stand alone in assigning this fauna to the Upper Cretaceous.

One thing is certain; we have to do with more ancient types than those of the Oligocene of Europe, from which some European palæontologists would derive the fossil Mammalia of Argentina, *à travers* the African continent. In several forms we see an approach to the Lower Eocene, Puerco fauna, of North America. *Notostylops*, for example, has as many claims to be a primitive Edentate as some of the Puerco fossils recently described by Dr. Wortman. The relation to the Puerco fauna is acknowledged by Señor Ameghino himself, when assigning several forms to the Phenacodontidæ and Periptychidæ, "the oldest representatives of the Condylarthra."

What the author's reasons are for considering the Primates of these *Pyrotherium*-beds as the ancestors alike of extinct and recent lemurs and of monkeys, cannot be seen from the paper before us. What strikes us in the figures, notably of *Notopithecus* (p. 4), is the mode of abrasion of the teeth, quite unusual for Primates, and leading to the supposition that these creatures were neither insectivorous nor frugivorous.

Of Rodentia very little is said in the present lecture; from the former paper we learn that they were provided with *two* premolars. If these Rodents are really hystricomorphous, this character alone would justify us in considering them as the forerunners of the Tertiary "hystricomorphous" Rodents of Europe, and not vice versa.

The figures intercalated in the text seem to be accurate as far as they go; but they are insufficient, being mere pen-and-ink sketches, such as a travelling palæontologist would sketch in his notebook.

On the whole, this preliminary notice of the *Pyrotherium*-beds fauna is just sufficient to satisfy the curiosity of the naturalists at large, and to excite in the highest degree the curiosity of the specialist. For a fuller knowledge of the characters of this fauna, we have to await the publication of the promised Memoir.

REPORTS AND PROCEEDINGS.

Geological Society of London.

The first meeting of the session 1897–8 took place on November 3, 1897. Dr. Henry Hicks, F.R.S., President, in the Chair.

The President read a letter received from the Secretary of State for the Home Department conveying Her Majesty's gracious reply

to the Congratulatory Address submitted to her, on the occasion of the Sixtieth Anniversary of her Accession, by the President, Council, and Fellows of the Society.

The Secretary announced that Lady Prestwich had presented to the Society a half-length portrait, in oils, of the late Sir Joseph Prestwich, painted by Mr. W. E. Miller.

Mr. W. W. Watts proceeded to give details of some interesting geological features recently exposed at the new Sewerage Works at Carshalton, Surrey, now being made by the Urban District Council, to which the attention of the Society had been directed by the Surveyor during the autumn recess.

These excavations are situated at a spot which on the Geological Survey Map is coloured as London Clay; and the features of the ground fully justified this colouring. The excavations, however, have shown that there are loamy and sandy beds of a light-yellow colour, some 14 or 15 feet in thickness, and apparently occupying a hollow in the London Clay. At the base these sandy beds become dark and clayey in some places, and include flints and pebbles, while below this is the London Clay. In the dark pebbly layer were found a large skull, a piece of a tusk, and a number of smaller bones, which Mr. E. T. Newton has determined to be a piece of elephant tusk, the skull (31 inches long) of *Rhinoceros antiquitatis* with some of its limb bones; while the smaller bones represent two or perhaps three horses. Although the teeth of the rhinoceros are wanting, the skull is otherwise very perfect; and, bearing this in mind, as well as the fact that certain of the limb bones were also found, and that *Elephas* is represented by the tusk, and all three (it is said) at a depth of 14 or 15 feet, little room is left for doubting that we have here at Carshalton a Pleistocene deposit of a somewhat unusual character and at a spot where it was not before suspected.

Mr. Whitaker, who was responsible for the geological mapping of this district, pointed out how the general configuration of the district gave no clue to the presence of this deposit of loamy sand, which occurred on a gentle slope, and that even now it was only possible to mark it on the map as an oval patch round the excavations with uncertain boundaries. The Drift shown, moreover, differs from that of the neighbourhood in that the latter is essentially gravel, while the former is sand, with loamy beds, but, as a rule, not stony, so that there are no surface indications of gravel.

The mammalian remains are now preserved in the Museum of Practical Geology through the kindness of the District Council.

Lieutenant-General McMahon, V.P.G.S., having taken the chair, the President made a communication regarding very similar deposits to those above described occurring in North-Western Middlesex. Some years ago he described sections in Glacial Drift on the Hendon plateau exposed during sewerage operations. More recently the sewers have been carried on at lower levels between Hendon and Edgware, and numerous remains of the mammoth and rhinoceros have been found resting on an eroded surface of London Clay, and

covered over by about seven feet of stratified sands, gravels, and brickearth. These deposits were found to spread out for considerable distances over the plain, and to be cut through also by the Silke stream, a tributary of the Brent. This area has hitherto been supposed to consist almost entirely of London Clay, but the sections have now shown that the brickearth, which in many respects simulates the London Clay, is underlain by deposits which must be classed as of Pleistocene age.

The President then resumed the chair, and Mr. H. B. Woodward called attention to a block of quartzite from Criccieth, in Carnarvonshire, which had been sent for exhibition by Mr. G. J. Day. The rock contained a band of disrupted clayey material which presented on the surface of the block a rude resemblance to hieroglyphics. He thought that the curious structure had been produced on a seashore bounded by clay cliffs, where a film of mud had been spread over the sands; and that the mud had dried and curled up before other layers of sand had been accumulated on the top of it. Similar phenomena might be produced at the present day on the Cromer coast, where thin films of mud were in places spread over the sands of the seashore. It had been suggested that the appearances in the Criccieth stone might have been produced in the original deposit during the irregular solidification of the sand and its included layer of mud. The rock itself was regarded by the President as probably derived from the Harlech Grits, in which he had observed somewhat similar features.

Mr. Bauerman, as one of the three Delegates appointed by the Council on behalf of the Society to attend the recent International Geological Congress, held at St. Petersburg, gave a short account of the work of the Congress, dwelling more particularly on the excursion to the Ural Mountains, in which he had taken part.

The following communication was read:—

"A Contribution to the Palæontology of the Decapod Crustacea of England." By the late James Carter, F.R.C.S., F.G.S. (Communicated by Professor T. McKenny Hughes, M.A., F.R.S., F.G.S.)

This paper deals mainly with the Brachyura. The author describes several new species, belonging to the genera *Nephrops*, *Gebia*, *Homolopsis*, *Ranina*, *Mithracia*, *Neptunus*, *Actæposis*, and *Goniocypoda*. The genera *Gebia*, *Ranina*, and *Neptunus* have not been previously recorded from British rocks. *Dianlax* is for the first time identified from the Tertiary strata — a single specimen having been found in the Middle Headon. *Platypodia Oweni*, Bell, is now referred to the genus *Dianlax*; and *Palæocorystes Broderipi*, Bell, to the genus *Eucorystes*.

As a result of the careful study of large series of specimens in various collections, the author is able to give much additional information concerning the morphology of several species.

CORRESPONDENCE.

SCANDINAVIAN ICE AND NORFOLK DRIFT.

SIR,—In the article which appeared in the October number of the GEOLOGICAL MAGAZINE, I called the attention of Sir Henry Howorth to the evidence for the former presence of an ice-sheet blocking the North Sea during the period of maximum glaciation, based on the deflection of the ice-striæ along the eastern coast of Scotland. Owing to that article having been written during my holiday in Norfolk, and in the absence of the numbers of the Magazine previous to that of August, I had overlooked the fact that Sir H. Howorth had dealt with this problem in the April number of the Magazine, and had deliberately rejected the hypothesis. I now ask for permission to express my regret for this oversight.

While on this subject, may I be allowed very briefly to state the conclusions regarding the mode of formation of the Drift of North Norfolk, at which I have arrived from an examination of the sections along the coast and inwards about Cromer and Sherringham. I now altogether abandon the view which I had held before this visit—that the Drift deposits owe their origin to an ice-sheet stretching from Scandinavia across the North Sea; and to this extent I find myself in agreement with Sir Henry Howorth and Mr. F. W. Harmer, who reject the ice-sheet theory as applied to this part of England.[1] As regards the Boulder-clay laid open for miles along the coast, we have a formation fairly uniform in character, distinctly laminated, and not excessively laden with erratic stones and boulders. This is not the kind of deposit we should expect from an ice-sheet, nor does it bear a resemblance to the Till (or Lower Boulder-clay) of the north-west of England and Scotland. It appears to me to be a distinctly aqueous deposit, resembling (except in colour) the Upper Boulder-clay of that region. What I believe I did see in these cliff-sections was a deposit precipitated over the floor of the sea in muddy waters, fed by glacier rivers, crowded with ice-floes and bergs, from which the erratic blocks fell down and became imbedded in the soft mud. Larger bergs of ice were also present, piloting along those huge masses of chalk such as are seen on the coast-section east of Cromer. Such conditions as the above would explain the occurrence of blocks and stones derived from various sources. The overlying "Interglacial sands and gravels" are also clearly marine deposits, but laid down in shallower waters than those of the Lower Boulder-clay, waters generally clear and free from muddy sediment. The manner in which the gravels rest on an eroded surface of the Boulder-clay shows that the sea-bed had become very shallow, and that changes in the physical conditions of sea and land had taken place; the change in the character of the deposits being

[1] "On the Pliocene Deposits of Holland": Q.J.G.S., November, 1896, p. 775. Mr. Harmer says: "It is difficult to see how the Baltic Glacier could have reached East Anglia, though ice-floes with Scandinavian boulders might easily have done so."

sharp and decisive. These beds of stratified sand and gravel reach a level of 320 feet at the "Roman camp" above Upper Sherringham, giving the minimum amount of the submergence at this epoch and in this part of East Anglia. EDWARD HULL.

OBITUARY.

REV. PROFESSOR HAUGHTON, D.C.L., F.R.S., F.G.S.

BORN 1823. DIED OCTOBER, 1897.

AT the close of the month of October last there passed away, in his 75th year, one of Ireland's most eminent sons, whose name stands at the head of this notice, and who must have been well known to many readers of the GEOLOGICAL MAGAZINE. The late Dr. Haughton came of a Carlow family, and at an early age entered Dublin University, of which he afterwards became so distinguished an ornament. Graduating in 1844, he took the senior mathematical moderatorship and gold medal, and in the same year obtained his Fellowship at the first trial; a performance almost unique in the history of the University. Those only who know what a tremendous test of mathematical and classical knowledge the examination for a Fellowship in Trinity College really is, can fully realize the greatness of this mental achievement.

The writer well remembers the first time he saw Haughton. The examinations for "littlego" were about to commence, and we were all seated at our desks waiting for the distribution of the papers, when a side door opened, and Jellett (afterwards Provost) and Haughton entered together. Both were in the prime of youth and vigour, both had reached the goal of Fellowship; and the writer was struck by the extreme beauty of countenance exhibited by the former, and the quick glance and decisive step of the latter, indicative of the restless activity of the mind within.

Most men in attaining a similar position elect to devote their time and talents to the cultivation of one branch of "natural knowledge" or research. It was otherwise with Haughton. His avidity for investigation in many directions was insatiable, and there were few subjects which he did not study in turn. His mind had essentially a mathematical bent, but he had also a strong leaning in the direction of physical and biological subjects. Hence he studied chemistry, geology, physical geology, and biology, with never-tiring devotion, and thus qualified himself for the great work he had kept in view—the development of the range of subjects to be taught in the University curriculum. Two years after obtaining the Fellowship he entered Holy Orders, and in 1847 was appointed Assistant Divinity Lecturer. But Divinity was not Haughton's strong point. The University School of Medicine was the object upon which he had determined to concentrate his energies, in order to its development and greater usefulness. With this object in view he studied medicine and surgery, taking the degrees of M.B. and M.D. in 1862. Thus fully equipped by this course of study, he proceeded to

reorganize the Medical School, and being liberally supported by the Provost and Board with funds, additions were made to its buildings and equipments. A new chemical laboratory (now under the direction of Professor Emerson Reynolds) was built, and a spacious anatomical museum was erected and well furnished with typical specimens for the use of students. Thus provided with all appliances, and with the objects of practical study afforded by the Dublin Hospitals, it is not surprising that the Dublin University Medical School ranks second to none amongst the institutions of this kind in the British Islands.

Nor did Dr. Haughton neglect original investigation into many curious problems of natural history. As Secretary to the Zoological Gardens in the Phœnix Park, Haughton had many opportunities for studying the habits of the inmates; and one of the most remarkable of his experiments was that by which he endeavoured to determine the relative strength of the lion and tiger. The writer cannot find an account of this experiment in "The Principles of Animal Mechanics," and has to depend on his memory alone. As far as he recollects, the trial was tested by the number of men hauling at a rope required to pull the fore-paw of each animal through the cage against its will. The experiment was decided in favour of the tiger, so that "the king of beasts" was dethroned from his position of eminence. A more important series of experiments was that on the muscular strength carried out by measurements of the cross-section of the muscles of various animals, resulting in the general proposition that "the work done by the contraction of a muscle is proportional to its length and area of cross-section conjointly."[1] These experiments, like most of those undertaken by Haughton, were worked out by accurate mathematical formulæ.

To geologists, the investigations which were of greatest interest, were contained in his papers on the Irish granites, in which he was able to show by chemical analyses that in each granitic region (and of these there are four) there are representatives of the soda and potash varieties.[2] At the time these papers were published, microscopic analysis had not come into use; and although more recent observers, with the aid of thin sections under the microscope, have examined these rocks, it has not been shown that Haughton's conclusions can be shaken. Another interesting set of observations were those carried out by Dr. Haughton and the writer on the Vesuvian lava-streams from specimens ranging throughout a period of 237 years (from 1631 to 1868), which resulted in showing that both in chemical composition and mineral structure no important change had taken place throughout this period.[3]

Besides his numerous contributions to the transactions of learned societies, Haughton, in concert with his friend and colleague, the late Rev. J. Galbraith, brought out a series of textbooks, designed

[1] "Principles of Animal Mechanics," p. 443.
[2] Q J G.S., vol. xii, pp. 171, 188; and vol. xiv, p. 300.
[3] Trans. Roy. Irish Acad., vol. xxvi (1876).

chiefly for students, which had a wide circulation, and were known as "Galbraith and Haughton's Manuals." These dealt with the following subjects: "Euclid," "Plane Trigonometry," "Mathematical Tables," "Mechanics," "Optics," "Hydrostatics," "Tides," "Astronomy," "Steam-Engine," "Algebra," and "Arithmetic." The publication of these Manuals gave rise to the following parody, taken from David's lament over Saul and Jonathan: "Galbraith and Haughton were beautiful in their lives; and in their Manuals they were not divided!" In 1865, however, Haughton published a Manual of Geology, by himself; Longmans and Co., 8vo, pp. 360 (see GEOL. MAG., Vol. II, 1865, p. 449).

Other works were the "Principles of Animal Mechanics," a book of extreme interest and originality, published in 1873, and "Six Lectures on Physical Geography" (1880). Meanwhile, well-merited honours were falling thick and fast on Haughton. In 1853 he was elected a F.G.S., and F.R.S. five years later (1858). He filled the offices of President of the Royal Irish Academy and of the Royal Geological Society of Ireland. Oxford conferred upon him the honorary degree of D.C.L. in 1868, and Cambridge followed suit a few years later, in 1880, while Edinburgh added her LL.D. in 1884; and that he was the life and soul of many Dublin societies and institutions, need scarcely be said.

Of Haughton's personal character little need here be stated. He was a general favourite with those who knew him; and when he rose to speak in public his trenchant manner of dealing with his subject, combined with an overflowing fund of humour, sometimes spiced with sarcasm, at once rivetted attention. In advocating or opposing a cause he was absolutely fearless of persons or of outside opinion, and undoubtedly he exercised great influence in the government of Trinity College. Those who, like the writer, were sometimes in his company at the dinners of the Dublin Geological Club, are not likely to forget the unfailing flow of wit and anecdote which kept the company in a state alternating between delight, amusement, and, it must be added, sometimes horror! In literature the *Noctes Ambrosianæ* of Professor Wilson afford the only parallel. E. H.

PROF. CONSTANTIN BARON VON ETTINGSHAUSEN.

BORN 1826. DIED FEBRUARY 1, 1897.

THE Baron CONSTANTIN VON ETTINGSHAUSEN, who was born at Vienna in 1826, and died at Graz on the 1st February of this year, shares with Heer and Saporta the merit of having, more than any other workers, advanced our knowledge of the Fossil Flora of the Tertiary period. This was the chief, although not the exclusive field of his astounding activity, which extended over a period of forty-seven years, from 1849 to 1896.

He graduated as a Doctor of Medicine in Vienna, beginning his scientific work almost immediately afterwards. After having been for a few years an Assistant in the Geologische Reichsanstalt, he became Professor at the Medical and Surgical Military Academy at

Vienna, the "Josephinum," which post he occupied from 1854 to 1871. In the latter year he received a call, as Professor of Botany and Palæophytology, to the University of Graz, where he remained until his end.

Most of his contributions to science are embodied in the publications of the Vienna Academy, notably the extensive Memoirs on the Tertiary Floras of Bilin, Sagor, Parschlug, Schönegg, Radoboj, Leoben, and others. Besides, he contributed papers to the Proceedings of the Royal Society of London on the Floras of Sheppey and of Alum Bay; and to the Palæontographical Society of London, the first volume of "A Monograph of the British Eocene Flora" (1879), in collaboration with Mr. J. Starkie Gardner. Other papers, chiefly on the Fossil Flora of Australia and New Zealand, are to be found in the GEOLOGICAL MAGAZINE, in the Quarterly Journal of the Geological Society, in the Memoirs of the Geological Survey of New South Wales, and in the Transactions and Proceedings of the New Zealand Institute.

Several collections brought together by Baron Ettingshausen are exhibited in the Geological Department of the British Museum; and at the end of the Seventies and later on, he made several lengthened stays in London, occupied with the rearrangement and critical examination of parts of the Phytopalæontological Collections in our National Museum.

Of him was said in 1884—"Coupled with his great powers of accurate observation and strictly scientific method of investigation, Ettingshausen displays an unusually broad grasp of the deeper problems which palæobotany presents, and has undoubtedly been for many years far in advance of all his contemporaries in this field in correctly apprehending and announcing the true laws of phytochorology and plant development." [1]

THE REV. P. B. BRODIE, M.A., F.G.S.

BORN 1815. DIED NOVEMBER 1, 1897.

THE REV. PETER BELLINGER BRODIE, M.A., F.G.S., whose life we recorded among our "Eminent Living Geologists," in the November number of this Magazine (pp. 481–485), passed peacefully away on the 1st November, at his residence, Rowington Vicarage, near Warwick, in his 82nd year. The notice of his life and his portrait, which appeared in our last monthly issue, tell all we have to record of this most excellent man and geologist. He was a Fellow of the Geological Society for sixty-three years. His memory will be warmly cherished by a wide circle of friends and geologists, many of whom he led on and encouraged by his enthusiasm to take up the hammer and join the ranks as field-naturalists and fossil-collectors in Warwickshire and elsewhere.

[1] Lester F. Ward, "Sketch of Palæobotany": 5th Ann. Rep. U.S. Geol. Survey to the Secretary of the Interior, 1883–4, p. 380. Washington, 1885.

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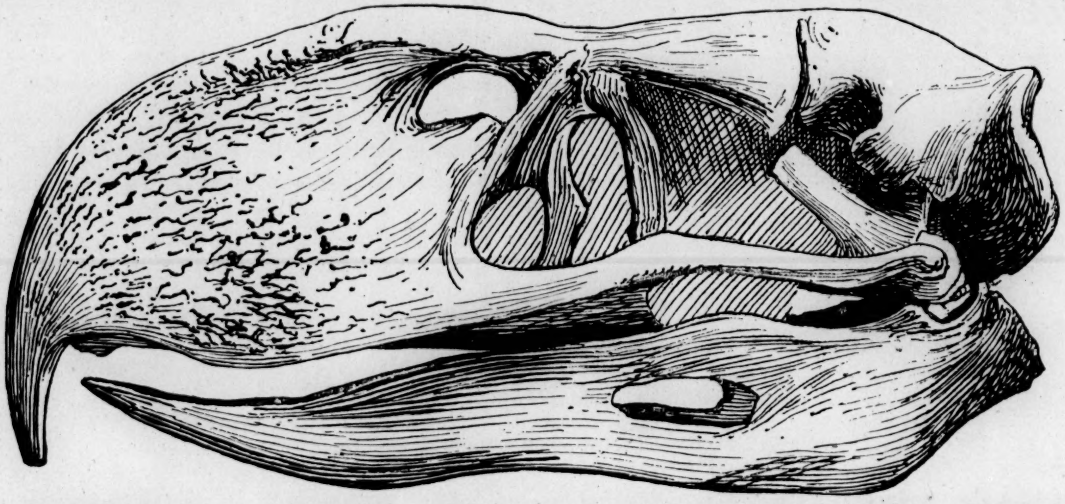

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